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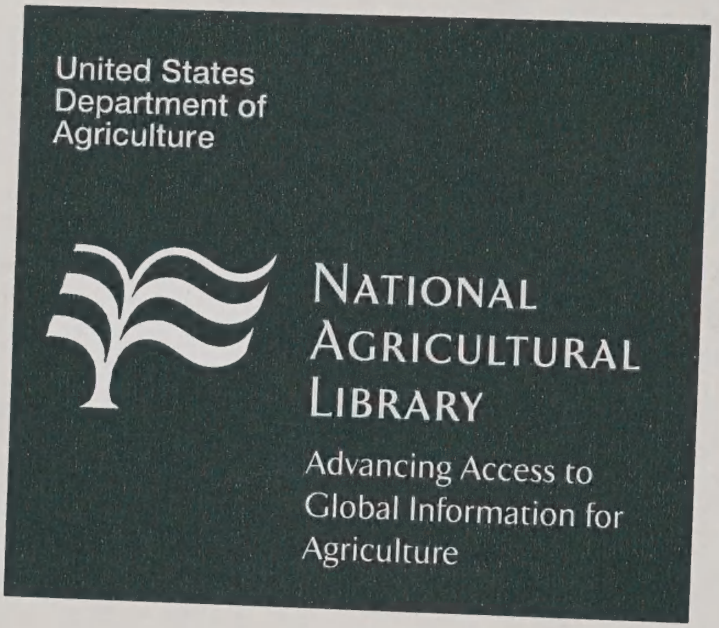
FORAGE, RANGE AND PASTURE

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The Task Force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The Task Force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the Task Force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

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Preface

Forage, Range, and Pasture Research Needs Through 1977

Authority: The Joint Task Force on Forage, Range, and Pasture research was appointed in memoranda of Dr. G. L. Mehren, Assistant Secretary of Agriculture, dated January 10, 1968, and Dr. A. G. Hazen, Chairman, Experiment Station Committee on Organization and Policy, dated January 16, 1968.

Membership:

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Consultants: Individual Task Force members contacted a large number of specialists in assembling and reviewing portions of the report for which they were responsible.

Staff Secretary: W. C. Dachtler, RPDES

Assignment: Forage, range, and pasture research in Research Problem Areas 112, 207, 208, 209, 307, 308, 309, 405, 406, 407, 408, 501, and 504 was assigned to this task force. In addition to assigned Research Problem Areas, the task force identified forage pasture and range research needs in Problem Areas 110 and 601.

Within the general framework of the Long Range Study (LRS), the Task Force was instructed to indicate areas of research that should be emphasized and to determine the most effective procedures for organizing and conducting the research.

Cooperative research conducted by SAES and USDA workers has made substantial contributions to improving forage, range, and pasture production. But too frequently maximum benefits from specific projects have not been realized because work was conducted and interpreted without regard to developments in related fields of endeavor. Attempts have been made to organize centers of excellence for forage, range, and pasture research, but these have not been fully realized because of serious deficiencies in

manpower, facilities, financial support, and communications.

Several factors make forage, range, and pasture research complex and challenging. These include: The large number of annual and perennial plants used for forage, range, and pasture; the high chromosome number and complicated breeding behavior of most forages; the wide range in management practices to which they are subjected; the diverse and often rigorous environmental conditions under which they are grown; the time required and the complexity of evaluating perennial species and management practices; the need to relate forage characteristics to animal performance; and the fact that, in general, forage value is not realized until marketed through livestock.

Progress in specific areas, such as the isolation of disease-resistant germ plasm in a given perennial forage crop, may have little impact by itself. The disease resistance must be incorporated into an adapted variety before it makes a contribution. Acceptance of the variety may still depend on the development of appropriate management practices to obtain optimum yields of quality forage. Information would also be needed on seed production potential, feeding value, yield of animal products, and economic return in relation to alternative crops and feeding systems.

The task force recognizes the serious consequences of fragmented research in forage, range, and pasture, and recommends further development of integrated research programs at selected locations. These centers should provide competence in the many disciplines required for the solution of critical problems, as well as maximum benefits in research productivity, training, and the utilization of scientific personnel. In certain subject matter areas, such as basic seed physiology and improved forage handling, one or a very few centers of intensive effort might well serve the entire country. In other subject matter areas intensive effort might be organized on a regional or sub-regional basis. The USDA and SAES should keep this objective in mind in allocating funds appropriated for this program.

Situation: Forage, range, and pasture is a multiple-use resource, the total development of which is a major factor in the economy. About a billion acres or approximately half of the land area in the United States is occupied by forage crops, pasture, and range. Approximately 800 million acres, largely rangelands, are found in the 17 Western States, with the remaining 200 million acres in the Eastern States. Cultivated grasses and legumes for pasture and conserved feed are important crops in all States. They provide, together with native range, the basis for cattle and sheep production. Forage producing lands are closely associated with water problems for they occupy important watersheds and influence profoundly water quality and the flow of rivers within their boundaries. They are indispensible in reducing soil erosion and water loss through runoff. Forage, pasture, and rangelands are important throughout the country in furnishing food and cover which support large numbers of big game, small game, and other wildlife of high recreational value.

It is difficult to estimate the value of all grazing lands in terms of erosion control, water conservation, recreation, beautification, and improvement of soil structure and fertility. However, the annual input of forage, range, and pasture to the production of livestock products has been placed at 8 billion dollars. (This estimate is based on data showing that dairy cattle obtain 2/3 and beef cattle 3/4 of their feed units from forages.) Thus, the estimated value of forages for feed alone nearly equals the combined cash receipts from cotton, soybeans, wheat, tobacco, and rice. The value of the corn crop, about 85% of which is fed to livestock, averages about 60% that of forages.

At least 90 grasses and about 30 legumes are of major importance for grazing and/or the production of stored feed. Alfalfa and alfalfa-grass mixtures grown for hay in the United States occupy about 30 million acres and provide more than 50% of the total hay required by livestock. Clovers and/or special purpose legumes, such as lespedeza, birdsfoot trefoil, and the vetches, are widely grown in every State on farms and ranches for hay, pasture, silage, seed, and soil and water conservation. Grasses provide 48% of the total livestock feed requirements as pasture and about 12% as hay. In the 17 Western States range and pastures provide from 50 to 60% of the total feed for beef cattle in nine states and 70% or more in the remaining eight. It has been estimated that western ranges and pastures support 18 to 20 million animal units (beef cattle, sheep, deer, and elk).

Grass and legume seed crops estimated at 800 million pounds annually provide income on nearly 300,000 farms. This seed is valued at approximately $175,000,000 to seed growers. Domestic seed production of many grasses and legumes is 10 to 40% below national consumption. Seed production of forage crops is uniquely different from that of cereal, fiber, and oil crops in that much of the seed is grown a thousand miles or more from its intended area of usage. Unless suitable precautions are taken, this may cause major shifts in gene frequencies within a variety that will affect persistence and yield in forage producing areas.

Weed and brush invasion is a serious problem on some 320 million acres of grazing land. Loss of certain desirable forage species has resulted in only marginal production on some 163 million acres of permanent grazing land. It is estimated that soil erosion and unfavorable soil conditions such as rough terrain and soil acidity have greatly limited the productivity of 229 million acres. Forages can contribute to improving productivity of these lands. Unfortunately, establishment and maintenance costs with available varieties and management practices usually are too high for economical returns.

The LRS indicated that agricultural production should be increased one-third by 1980 and doubled by 2000 to meet estimated needs. This is, of course, an average for all production with some products increasing more rapidly than others. Beef is among the products for which demand is expected to increase most rapidly. (Some have estimated a 45 percent

increase in the next 10 years.) Demand for milk will increase at a much slower rate because consumption per capita is declining.

Conversion of projected human needs for food into feed requirements of cattle, and more specifically into demands for forage, is difficult. However, some generalizations are possible. To achieve the 1980 and 2000 LRS goals, annual average productivity gains of 2.2 and 3%, respectively, would be required. Field crop output gains per acre have been in the 2.5 to 3% range over the past 15 years. It seems reasonable perhaps to expect similar gains in the next decade or two. However, over the past 15 years, reported gains in forage productivity have lagged behind those attained in most cultivated crops.

Assuming that LRS goals are met, percentage calf crops remain constant, and the proportion of beef cattle in feed lots remains the same as in 1966 (one of four), then by 1980 there would be at least 29 million cattle in feed lots (up 7 million) and about 85 million other beef animals on pastures and ranges (up 21 million). By 2000 there would have to be 44 million on feed and 128 million other cattle, twice the numbers in 1966. If continued increases in per capita consumption of meat occur, still greater beef cattle populations will be required. Making the projection for dairy cattle is more difficult because of the trend toward lower per capita consumption of dairy products, higher outputs per cow, and increasing use of milk substitutes. The decline in dairy cow numbers may level off some during the next decade.

Most overhead costs for cows are similar at all levels of production; thus, high producing dairy cows are the most profitable. Average annual milk production per cow has increased to 8,513 pounds, an annual increase of 220 pounds since 1957. Higher production per cow has required liberal grain feeding because available forages have not met nutrient requirements. Higher grain feeding increased production costs. In 1954, 30.2 pounds of concentrates were fed per 100 pounds of milk; in 1966, 37.8 were fed. DHIA data show that costs of concentrates fed per 100 pounds of milk were $0.91 and $1.12 in 1957 and 1966, respectively. The profitability of higher production is closely associated with the grain:milk price ratio. Since the dairyman has little control over prices of either commodity, the possibility of limiting cost or increasing profit through manipulation of this ratio is limited. Dairymen are now in a tight cost-price squeeze. Failure of grain crop production to increase sufficiently to provide for cattle feeding above the requirements for human consumption could result in higher prices and even smaller profits. This background emphasizes the importance in the next decade of providing dairy cattle with increased amounts of forage with higher nutritional value and intake levels, and at lower costs of production, handling, and packaging adapted to highly mechanized feeding and transport systems.

Only about one-fourth of the beef cattle in the country in any one year are in feed lots consuming high grain rations. Three-fourths are breeding animals, calves, etc., which receive about 92% of their feed units from

forage. This ratio might decrease slightly with time but could increase with higher priced feed grains. Therefore, for every additional animal in feed lots there will be about three more in breeding herds. Current and predicted future prices for beef calves and anticipated trends in feed grain prices suggest that large quantities of concentrates cannot be fed profitably to breeding herds. The practice of feeding roughages to cows in dry lot may become more common. Two predictions can be made with a high degree of certainty; namely, (a) vastly increased outputs of forage will be required in the next two decades, and (b) the greatest portion of this increase will be consumed by beef cattle.

Sheep and goats consume about 12 million tons of feed units (equal 1 lb. of corn) annually. More than 90% of these feed units are derived from forages, and 90% of the forage feed units are obtained from range and pasture. A high proportion of these feed units are provided by rangelands. Sheep and goats consume roughly 10 percent as many forage feed units as do beef cattle. Demands for lamb, mutton, and wool lag behind those for beef and dairy products. Yet demands for these products probably will increase nearly one-third by 1980 and will double by 2000 A.D.

Forage improvement objectives may require revision in the next decade as a result of new developments in forage processing and feeding. Increasing yield of digestible nutrients per acre would attain even greater importance if research shows that non-protein nitrogen can furnish a larger fraction of the protein now fed to ruminants. The importance of quality in forage yield may also change if digestibility can be increased economically by chemical or mechanical treatment. Such developments would significantly affect objectives in forage research but not in the area of pasture and range improvement.

The productivity of range and pasture must be improved to meet the food needs of the American public. Progress in management of this vast resource will come through increased understanding of the ecology and physiology of pasture and range plants. Techniques to control and replace undesirable plants with more desirable species will lead to greater outputs. Simultaneously, the ever-increasing demand upon these lands for water, wildlife, recreation, timber, and other uses will be realized in conformity with the precepts of multiple-use management.

Value of forage, range, and pasture in livestock production exceeds 12 million dollars per SMY input. Other values of forage, range, and pasture would materially increase value per SMY. Returns per additional SMY input should be higher than in many other commodity areas.

Recommendation 1: The task force recommends protection and production research be distributed among 38 specific objectives within the production RPAs. The recommended research will provide needed technology to increase efficiency in forage, range, and pasture production, as well as improved techniques for maintaining and restoring the range and pasture resource.

In some RPAs, increases beyond those projected by the LRS Joint Committee (JC) were considered essential in meeting production, restoration, and conservation goals identified in the Long Range Study. These adjustments are as follows:

a) RPA 110, Appraisal of Forest and Range Resources.

The serious lack of information on the extent and productivity of pasture and rangeland underscores the urgent nature of developing a national inventory and in providing methodology that will furnish meaningful data. The importance of this assignment as a guide to research planning and resource management was recognized by the Forestry Task Force. This task force agreed with the Forestry Task Force and recommended a staffing level that could complete a major portion of the work within a 15-year period. An increase in effort on the national inventory is projected between 1972 and 1977, but this increase is offset in part by a reduction in research under RPA 110-B.

b) RPA 112, Range Management.

This RPA by definition includes all aspects of range management like weed and brush control, entomology, plant pathology, economics, etc. Staffing levels recommended by the Joint Committee were considered inadequate to provide low cost, efficient practices for maintaining and improving the range resource. Critical range problems include the loss of once-productive rangelands, erosion, declining water yields, and reduced recreational opportunities. Progress has been made in coping with these and other problems, but in many regions the continued depletion of this resource exceeds attempted restoration. Research that will enable operators to reduce costs and increase the efficacy of range improvement practices is required to meet our obligation to preserve this valuable resource for future generations. The addition of 27 SMYs over the Joint Committee 1977 recommendations are viewed as essential to providing effective research on the complex production problems that characterize all rangelands.

c) RPA 207, Insect Control, and RPA 208, Disease Control.

The Joint Committee recommendations are realistic because of the existing base in these two RPAs. The task force did not recommend any adjustments in SMYs.

d) RPA 209, Weeds and Other Hazards.

Weed control in forages, as well as the control of brush and noxious plants in pastures, has not kept pace with progress in cultivated crops. Lack of research effort on improved application techniques, biological control, and the ecology of specific weeds has created serious problems in the establishment and maintenance of forage plants. The task force

recommends an additional 7 SMYs above the Joint Committee 1977 projections. This level of support is needed to reduce forage losses due to weeds and thereby increase productivity.

e) RPA 307, Biological Efficiency.

The major portion of forage research is conducted under RPA 307. Research on a substantial number of forage species is superficial, in spite of the 277 SMYs included in the 1966 inventory. This can be explained by the diversity and the complexity of the problems as identified in the "Situation" statement, and by the shortage of well established principles that can be modified for use in improving production efficiency in specific areas. In fact, the competitive position of many forages has eroded because advances in relevant technology have been less than that achieved in most field crops. In order to meet this obvious need for well integrated and adequately staffed research programs, the task force recommends an increase of 35 SMYs over the Joint Committee 1977 recommendation. This level of staffing will be necessary to develop effective cooperative research among agronomists, geneticists, pathologists, plant physiologists, weed scientists, soil scientists, agricultural engineers, economists, biochemists, and animal scientists.

f) RPA 308, Mechanization.

Forage harvesting and preservation is a major problem in improving the efficiency of forage production and use. It is evident that the competitive position of forages has suffered from rising production costs and heavy harvesting and storage losses. Recognizing the critical nature of harvesting and farm processing problems, the task force recommended an increase of 9 SMYs over the Joint Committee 1977 projection. Comparatively modest levels of support were allocated to forage establishment and seed production research. The task force recommendations are based on the lack of research on forage harvesting and on farm processing by private industry, and realization that gains in biological efficiency demand improvement in forage harvesting, processing, and preservation.

g) RPA 309, Systems Analyses.

Systems analysis is essential to improving the efficiency of forage and pasture use in livestock production. Research must be conducted in more than one region in order to establish the relative merits of alternative crops and feeding practices. The task force recommended the addition of 7 SMYs over the 1966 inventory of 2 SMYs.

Recommendation 2: Utilization and marketing research represents a comparatively small proportion of the total effort on forage and pasture crops. There are good opportunities, however, to improve the quality of processed forage products and to expand domestic and foreign markets for these products and forage seed. These opportunities for research are recognized by several adjustments in the Joint Committee recommendations.

a) RPA 406, Food Products.

The tremendous potential for producing low cost leaf protein of high biological value for human food are recognized in the asking for 3 SMYs by 1972 and 6 SMYs by 1977. Leaf proteins have a high potential for providing high quality, low cost proteins for protein-deficient areas of the world.

b) RPA 407, Feed and Non-food Products.

The success of dehydrated alfalfa products will be enhanced by continued research. Additional SMYs will be needed, however, to extend these investigations and to include other major forage species, especially those characterized by high yield potential and comparatively low quality. The task force recommends an increase of 11 SMYs beyond the Joint Committee 1977 projection.

c) RPA 501, Improved Grades and Standards.

The development of processed forage products will require improved grades and standards for acceptance and orderly marketing. The task force recommends the addition of 3 SMYs by 1977.

d) RPA 504, Marketing Efficiency.

Improved marketing practices are needed to insure adequate seed supplies of improved forage varieties. The task force recommends that two additional SMYs be provided for these investigations.

e) RPA 601, Foreign Markets.

Opportunities exist for developing improved forage products for export purposes. The task force recommends the addition of 3 SMYs in this research problem area.

Recommendation 3: Many forage, range, and pasture problems can be solved only through well integrated, interdisciplinary research. Although this need is identified in the preface, the task force felt that these complex research problems should be emphasized in a specific recommendation. In implementing this report special attention should be given to developing regional centers of excellence for forage, range, and pasture research.

Summary of Inventory and Recommendations

Research Problem Area	1966 1/ Inventory	1972 JC Recom. 2/ SAES	1972 JC Recom. 2/ USDA	1972 JC Recom. 2/ TOTAL	1972 TF Recom.	1977 JC Recom. 2/ SAES	1977 JC Recom. 2/ USDA	1977 JC Recom. 2/ TOTAL	1977 TF Recom.
110 Appraisal of forest and range resources					23				
112 Range management	154	77	88	165	181	93	111	204	
Subtotal - Range	(154)	(77)	(88)	(165)	(204)	(93)	(111)	(204)	(266)
207 Control of insect pests	57	50	27	77	79	64	34	98	98
208 Control of diseases	31	34	16	50	50	49	21	70	70
209 Control of weeds and other hazards	17	15	11	26	33	18	13	31	38
Subtotal - Protection	(105)	(99)	(54)	(153)	(162)	(131)	(68)	(199)	(206)
307 Biological efficiency	277	254	57	311	340	327	78	405	438
308 Mechanization	19	13	9	22	25	14	10	24	33
309 Systems Analysis	2				7				9
405 Consumer acceptability	3	3	0	3	3	3	0	3	3
Subtotal - Production	(301)	(270)	(66)	(336)	(375)	(344)	(88)	(432)	(483)
406 Food products	3/	3/	0	3/	3/	3/	0	3/	6
407 Feed and non-food products	12	6	9	15	25	8	13	21	32
Subtotal - Utilization	(12)	(6)	(9)	(15)	(28)	(8)	(13)	(21)	(38)
408 Market quality	6	1	7	8	8	1	8	9	9
501 Grades and standards	2	2	3/	2	4	2	3/	2	5
504 Market efficiency	2	2	3/	2	4	2	3/	2	6
601 Foreign markets					2				3
Subtotal - Marketing	(10)	(5)	(7)	(12)	(18)	(5)	(8)	(13)	(23)
GRAND TOTAL	582	457	224	681	787	581	288	869	1016

1/ 1966 Base (Volume 1, table 1, "An Inventory of Agricultural Research")

2/ Projected increases from joint committee of State and USDA Research Administrators, Chicago, Illinois, July 1967

3/ Less than one-half scientist man-year

TITLE: A national inventory of range and pasture resources. RPA 110-A

SITUATION: Native ranges and permanent improved pastures vary widely in productivity, soil stability, and potential importance for production of livestock, wildlife, and other uses. Many have important watershed values and about one-third is forested, including commercial and non-commercial forest lands.

With the increasingly varied and important contributions which the Nation's range resource can make to the overall social and economic well-being of the people, competition among uses is intensifying. The starting point for future enlightened stewardship of this great resource is wise land use allocation. Basic to land use allocation and multi-resource management decisions is a knowledge of the existing condition, character, and distribution of the mosaic of range resource components--soils, water, weather, timber, food, and cover plants--for both wild and domestic animals, and the various elements that provide outdoor recreation. Authoritative information on this is fragmentary and inadequate for a nationwide picture.

The need for a comprehensive nationwide range resource evaluation has been repeatedly voiced in recent years by range managers, scientists, and Members of Congress. One of our major weaknesses in developing a creative range research program is the lack of an adequate range resource inventory.

The lack of a comprehensive appraisal of the Nation's range and pasture resource is limiting the development of sound policies for conservation and development of both public and private rangelands. There is a definite need for implementing a coordinated nationwide inventory of range resources by range type, vegetation condition, soil, use, economic value, and site potential. There is likewise a need for continued evaluation of the prospective demands on the range environment.

OBJECTIVE: To characterize and classify the Nation's range and pasture resources to provide a sound basis for developing research policies and implementing resource development and management programs.

RESEARCH APPROACHES:

A. Collect and assemble essential information for each State on range and pasture resources and up-date information at 10-year intervals.

B. Analysis of information on range resources, future demands, and requirements.

C. Develop recommendations for public and private action programs. This would be a major part of the proposed research program leading to comprehensive reports like the Timber Resource Review. This would presumably be a joint effort among State and Federal agencies.

CHARACTER OF POTENTIAL BENEFITS: Resource data would provide up-to-date information on the quantity, quality, and present as well as potential productivity of range and pasture resources for evaluating future needs for Federal and State range multi-resource development and management programs.

MAGNITUDE OF POTENTIAL BENEFITS: An authoritative and comprehensive evaluation of our range and pasture resources would provide the proper perspective for sound guidance in the future role of these lands in the Nation's rural development and welfare. It would also be indicative of research needs, both as to kind and magnitude of programs needed to meet range resource problems.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
8	25

TITLE: Measuring range and pasture production. RPA 110-B

SITUATION: Range and pasture research and resource management have been hampered by difficulties in obtaining accurate quantitative measurements of vegetation, nutritive value for animals, forage quality, and other information needed for authoritative, low-cost inventories. Closely related to, and frequently measured with, forage yield are litter and soil characteristics such as taxonomic features, fertility, infiltration rate, and stability. Especially needed are acceptable criteria for evaluating resource conditions and present and potential site productivity. Aerial photography and related remote sensing devices, computer programming, and other methods offer promise in projecting trends and assessing rangeland conditions and livestock productivity. Survey techniques on areas of ranch unit size are used by Federal, State, and private landowners for making management decisions. Standardized inventory techniques need to be developed for a National Inventory of Range and Pasture Resources (RPA 110-A). For a broad inventory there is need to determine what the population attributes are and how best to sample them. Also, there is at present no overall agreement in the scientific community on a common unit to which data can be reduced.

OBJECTIVE: To establish efficient methods and techniques for measuring the major attributes of the range environment which will facilitate interpretation and evaluation of forage in terms of animal production and for other use demands upon the resource.

RESEARCH APPROACHES:

A. Utilize research information to establish sound and efficient criteria for expression of forage quantity and quality.

B. Develop standardized procedures for making a nationwide inventory of the range environment. (See 110-A)

C. Determine the most effective ways to assemble, analyze, and interpret data on vegetation, weather, and soils for evaluation of site potential and predicting fluctuation in annual forage production.

D. Develop and test remote sensing and other techniques for measuring or censusing vegetation parameters, soil stability, site attributes, forage utilization, animal populations and movements, and major facets of the range environments.

CHARACTER OF POTENTIAL BENEFITS: Outputs would provide scientists and managers the information to make more accurate and efficient evaluation of plant and animal responses to treatments imposed for research or for resource management purposes. Simple, accurate methodology would be available for conduct of a National Inventory of Range and Pasture Resources.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefits is included in 110-A. It would provide standardized procedures for reporting research and more meaningful and reliable inventories at the local and national level. In addition, the efficiency of scientists and land managers concerned with range and pasture problems would be greatly increased. Decision-making in the development of resource management plans and action programs for ranch unit size operations can be greatly enhanced, with substantial savings in dollars and manpower, together with significant increases in productive capacity.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
15	10

TITLE: Coordinated multiple uses of rangelands. RPA 112-A

SITUATION: Management of rangelands for multiple use is highly complex, not only because of variability among rangelands, but also because of the many social problems involved in allocating this valuable resource in accordance with its capability and the demands upon it. More than 300 million acres of Federal rangelands are managed for multiple uses under legislative enactment, and the remaining private rangelands are managed for greater economic return by incorporating several uses other than livestock grazing.

OBJECTIVE: To obtain basic information for improvement and management of rangelands for harmonious use by livestock and game animals, watershed protection, timber production, and recreational and scenic values.

RESEARCH APPROACHES:

A. Evaluate physical and economic factors for appraising site classification for multiple use management of rangelands.

B. Determine the suitability of native and seeded ranges for furnishing habitat requirements for wildlife, watershed protection, and high quality forage.

C. Determine how conversion of rangeland vegetation affects game habitat, watershed conditions, and livestock forage supply.

D. Evaluate competition between production of livestock and game animals and water.

E. Study economic relationships of livestock grazing and other land uses on the economy of local communities.

F. Economic analysis of various land uses as components of the income to ranch management.

G. Evaluate the influence of vegetation manipulation on water yield and sedimentation.

CHARACTER OF POTENTIAL BENEFITS: Improved coordination of livestock uses, timber production, recreation, wildlife, and water yield will increase human satisfaction and return from this land resource. Current information is inadequate for developing sound practices for multiple use management of rangelands. At present, multiple-resource management and assignment of uses are based primarily upon considered judgment with little benefit of quantitative data.

MAGNITUDE OF POTENTIAL BENEFITS: The vast grazing lands of the United States can serve the future demands of the American people only when managed in the most scientific manner for harmonious use of the total resource.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
38	47

TITLE: Improvement and management of rangelands. RPA 112-B

SITUATION: Improvement of rangelands and how they are managed offers great promise for meeting future demands upon the great wealth represented by the renewable range forage resource. Grazing management in combination with seeding deteriorated ranges, control of undesirable species, the use of fertilizers on certain vegetation types, water spreading, and pest control can add materially to the contribution of range forage to human welfare.

OBJECTIVES: To develop practical efficient improvement practices for restoring and improving range productivity.

RESEARCH APPROACHES:

A. Determine the relative value of seeded ranges for production of livestock, for watershed protection, and for restoring deteriorated ranges.

B. Investigate the benefits of fertilizers and legume seeding on various range forages with reference to 1) yield of nutrients, 2) vigor of forage plants, and 3) livestock response.

C. Evaluate mechanical structures such as contour furrows, trenches, and pits on rangelands to control runoff and erosion and to increase herbage yield through increased soil moisture.

D. Evaluate water spreading to increase forage yield through lengthening the growing season of forage plants, improving plant composition, controlling soil erosion, and preventing flood damage.

E. Study the effects of rodents, insects, and diseases on ecological changes in range ecosystems.

F. Develop methods to improve livestock distribution to increase the production of animal products and maintain range productivity.

G. Evaluate alternative grazing management systems and intensities of range use in combination with advanced range improvement practices.

H. Develop cost accounting budgets for range improvement practices.

CHARACTER OF POTENTIAL BENEFITS: Range forage is an important renewable resource that justifies development and management at or near full potential because it not only represents wealth to communities and the Nation but also furnishes protection to millions of acres of watershed, as well as food and shelter for game animals and other wildlife.

MAGNITUDE OF POTENTIAL BENEFITS: Limited research has shown that development and management of the range forage resource can increase big game and livestock production on rangelands from 2 to 3 times their present level. Realizing this goal could increase the returns from livestock alone by about one billion dollars annually.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
49	59

TITLE: Growth and development of range plants. RPA 112-C

SITUATION: Range plants grow under harsh environmental conditions. Severe droughts and wide temperature extremes are common hazards. Shallow, unstable soils, often characterized by low fertility, poor moisture relations, and high salinity are often troublesome. Under arid conditions root development, water use, and reserve carbohydrates are of great importance to the survival and yield of range plants. Millions of acres of rangelands can be made more productive through understanding critical stages in plant growth and development and limitations imposed by the environment, including the effects of pollution and weather modification. Identifying factors limiting vegetational response will contribute to the development of improved management practices that minimize the added burden of livestock grazing.

OBJECTIVE: To obtain basic information on the physiological and ecological factors limiting growth, development, and persistence of range plants, and to apply these findings in devising improved management practices.

RESEARCH APPROACHES:

A. Evaluate soil, climatic, and plant-animal stresses and their effects on range-plant growth and development.

B. Identify physiological and morphological characteristics associated with persistence and competitive relationships among range plants.

C. Study growth cycle of range plants, including cycling of carbohydrate reserves, tiller initiation and development, time of floral initiation, and effects of time and degree of defoliation on regrowth.

D. Investigate the autecology and synecology of major range species and range types.

E. Structure sound management practices that will permit use of forage without weakening plants or adversely affecting the site.

CHARACTER OF POTENTIAL BENEFITS: Improved management practices will result in higher carrying capacity and increased rangeland production.

MAGNITUDE OF POTENTIAL BENEFITS: Improved understanding of range plant development would contribute directly to the benefits identified under RPA 112-B.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
21	27

TITLE: Chemical and physical properties of range plants affecting animal performance. RPA 112-D

SITUATION: It has been observed that some range plants support a higher level of performance in grazing animals than do others. To a limited extent range plants may be evaluated and ranked on the basis of observed animal performance. This approach is superficial and expensive in view of the vast number of range plants available for use, and variation introduced by soil fertility, climate, stage of growth, and physiological differences among grazing animals. Clearly, more versatile and rapid methods of evaluating quality in range plants are needed if these differences are to be fully exploited.

The performance of grazing animals is directly related to differences among range plants in palatability, nutrient content, nutrient digestibility, toxic substances, and various combinations of these factors. Although these relationships are obscure, there is no reason to expect that these differences could not be explained and predicted on the basis of chemical and/or physical properties. Identification and selection of superior plant species and improved management practices could than proceed in a more orderly and objective manner.

OBJECTIVE: To determine quantitatively the chemical and physical properties of forage that are responsible for differential animal performance, develop chemical and physical methods for estimating the amount and nutritive value of herbage consumed by grazing animals, and identify those plant species and management practices that will provide grazing of greatest value.

RESEARCH APPROACHES:

A. Develop methods for determining range forage intake and digestibility in grazing animals and associated in vitro digestibility values.

B. Determine the nutritional characteristics of major and diverse range types by observation of intake, digestibility, and performance of animals in various physiological stages.

C. Determine the chemical and physical characteristics of plant material provided in B, including analyses and assays for minerals, carbohydrate fractions, nitrogen fractions, toxins, hormonal substances, fermentation inhibitors, and structural characteristics.

D. Identify the important positive and negative relationships between the chemical and physical characteristics determined and observed animal performance.

E. Relate and coordinate findings with selection and development of grazing systems - RPA 112-A, feed supplementation systems - RPA 112-B, factors affecting plant composition - RPA 112-C, and appraisal of range resources - RPA 110.

CHARACTER OF POTENTIAL BENEFITS: Improved animal performance and yield of animal products from available land area through selection and development of the most nutritionally valuable range plant material.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
16	21

TITLE: Range seeding. RPA 112-E

SITUATION: The western range is generally recognized as producing substantially below its potential. A large acreage, at least 100 million acres, has reached the stage of depletion where seeding will be required to provide adequate cover for protection and to restore productivity.

OBJECTIVE: To develop the knowledge of species, range sites, and techniques which, when properly combined, will permit efficient revegetation of depleted range that cannot be restored by methods other than seeding.

RESEARCH APPROACHES:

A. Evaluate range sites with respect to climate, soil, and overall value to society, as indicators of potential for successful seeding.

B. Evaluate seedbed preparation and seeding techniques, including season, rate, and depth of seeding, for species of value in range seeding to combine maximum likelihood of successful establishment with maximum economy for purposes of subsequent use.

C. Evaluate microclimatic relationships with respect to germination, root elongation, and seedling establishment for species and strains having potential value in range seeding. Particular attention will be given to studying the effect of temperature, wind, moisture, soil, toxic minerals, fertilizer (including legumes as a source of nitrogen), competing vegetation, rodents, insects and disease, and their interactions. Because the range is a highly heterogeneous area, all studies must be thoroughly instrumented in order to make interpretation of results clear-cut and useful in projecting to sites not studied directly.

D. Conduct breeding research to improve seed quality, germination, seedling vigor, and disease and drought resistance of seedlings in order to enhance chances of success of range seeding operations.

E. Develop or identify species suitable for seeding that have special merit for erosion control, longevity, drought resistance, salt tolerance, grazing tolerance, nutritional value, and palatability for game and livestock.

F. Conduct research into the physiological and biochemical behavior of seedlings when subjected to drought, heat, and cold in order to identify areas of strength and vulnerability in each species with respect to use in range seeding. Determine the value of preplanting seed treatments.

G. Design and develop equipment that will provide for adequate soil compaction, precision placement of seed, and improved moisture retention.

H. Develop equipment to move uprooted plants out of the way for planting and back on top of seeded row to provide shade and protection to new seedings.

I. Study the effects of herbicide residues on the growth of new seedings.

CHARACTER OF POTENTIAL BENEFITS: The high incidence of failure or near failure in range seeding will be markedly reduced, the rate of range improvement greatly accelerated. Watersheds will be improved with decrease in erosion, floods, and reservoir siltation. Streamflow will be better sustained (less seasonal), extending availability of irrigation water. Potable water supplies to cities will be improved. The habitat for game animals and fish will be improved as well as the environment for recreation. The western livestock industry will be strengthened by improved capacity and forage value resulting from seeded ranges.

MAGNITUDE OF POTENTIAL BENEFITS: The successful seeding of as many as 40 million acres of deteriorated arid range would conservatively increase the value of the range resource by 100 million dollars per year plus many intangible benefits. Breakthroughs in range seeding techniques could double or triple the estimated acreage that could be economically seeded.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
32	42

TITLE: Noxious range plant control. RPA 112-F

SITUATION: There are an estimated 320 million acres of the Nation's grazing lands infested with low-value herbaceous and woody plants. Much of this unwanted vegetation represents invasion of grasslands or increasing brush and tree densities. Much of this has come about because of past mismanagement, unwise attempts at cultivation, and other disturbances.

These noxious plant-infested lands are not only producing much below their forage yield potential but often these infestations reduce water yields, constitute a biological desert for wildlife, impede timber regeneration on forested range, and, where gullied, present ugly scars on the landscape. Fire hazards are frequently intensified by brush infestations, and costs for protection of property and life are greatly increased. Many brush and herbaceous weed species are poisonous or mechanically injurious, causing livestock losses by death or reduced weight gains.

Past research has made feasible the conversion or restoration of millions of acres which were infested with low-value plant species. Restoration has been accomplished by use of herbicides, machine clearing, fire, or a combination of these controls, often followed by seeding. In many situations, costs for control are too high or plant control methods ineffective. Information is lacking on the reasons for plant specificity and persistence of herbicides, and possible effects on wildlife. There is a continuing need to evaluate new herbicides and combinations of control methods. Also biological control by insects of a few brush and weed species has been effective and offers further promise for control of noxious plant species. But an expanded, realistically staffed research program is urgently needed to meet increasing brush and poisonous weed problems.

OBJECTIVE: To develop effective, low cost, safe methods for controlling unwanted range plants in the restoration or conversion of brushlands to lands of greater value for grazing and other uses.

RESEARCH APPROACHES:

A. Find more effective and selective herbicides for the control of weed and brush species, particularly those not controlled efficiently by present methods.

B. Intensify study of physiological and ecological investigations of unwanted range plants, including phreatophytes, to gain a better understanding of their growth cycles, reproduction, and spread.

C. Devise effective techniques in the use of fire, alone and in combination with herbicides, and machine clearing for control of low-value trees and brush.

D. Study the effectiveness of existing brush-killing equipment and make modifications and improvements.

E. Devise modifications in existing management practices that will contribute to the control of herbaceous and woody plants and impede their reinvasion of grazing lands, while at the same time improving productive capacity of the area.

F. Explore the feasibility and value of using diseases, insects, and other biological agents for controlling undesirable species.

G. Determine comparative costs and benefits of the most promising systems of brush and weed control on grazing lands.

CHARACTER OF POTENTIAL BENEFITS: Positive control of unwanted plants, which is now impractical or impossible, will be made feasible; costs of type conversion or restoration to productive grazing lands will be greatly reduced and phreatophyte control made possible.

MAGNITUDE OF POTENTIAL BENEFITS: Research in this area will be closely coordinated with RPA 112-A, 112-B, and 112-E, and with the program described under RPA 209. The benefits from control of noxious range plants, improved management, and range seeding could approach $600 million annually (see RPA 209-A) from increased yields of forage alone. Additional benefits would accrue from reduced livestock handling costs and enhanced values for wildlife habitat, recreation, and aesthetics.

RECOMMENDED RESEARCH EFFORT: The suggested level of support is based in part on projections developed under RPA 209.

TF Program Recommendations

1972	1977
21	28

TITLE: Systems analysis of grazing ecosystem problems. RPA 112-G

SITUATION: Range researchers and managers in the past two decades have accumulated considerable information about how range ecosystems operate and how they can be manipulated beneficially. Too often, however, this information is not synthesized, collated, or quantified. Furthermore, published information is distributed widely in journals, bulletins, books, and internal reports of research organizations. With the increasing amount of information available, reviews and, more important, syntheses of information must be undertaken to organize the large and diverse body of literature that characterizes range science. Even though gaps exist in our knowledge, it is desirable to bring together the information we have about range ecosystems. Such activities must be planned as part of the research and management efforts. These syntheses may be facilitated by developing quantitative models of grazing ecosystems or their components. These ecological models are mathematical or physical facsimilies of either complete ecosystems or some of their components. Models of a kind exist in the minds of the scientists and managers who express them in free-form English. These models are usually too vague and ill-defined to provide a solid basis for scientific study of ecosystem structure and behavior. The discussion and uses of ecological models is more profitable when restricted to models susceptible to quantitative formulation and testing. The quantitative model provides an essential guide to the design of an entire research program so that submodels can be developed and validated by field observations and experiments and fitted into a larger model. Quantification and the use of a standard mathematical terminology is also essential to range scientists and managers who hope to communicate effectively with specialists in other disciplines.

OBJECTIVE: To synthesize published and unpublished information concerning various problems in range ecosystem analysis and management and to develop mathematical models of ecosystem processes, components, and responses to manipulation.

RESEARCH APPROACHES:

A. To investigate, modify, and develop information storage, processing, and retrieval systems suitable to rapid analysis of management and research data on range science or grazing ecosystems.

B. To develop simulation models of grazing ecosystems or their components for evaluating management decisions subject to uncertainty, such as weather variability.

C. To explore, develop, and examine optimization models for alternative grazing ecosystem use decision problems.

D. To examine, develop, and modify systems analysis and operations research techniques to extract new information about grazing ecosystem resource systems.

CHARACTER OF POTENTIAL BENEFITS: As grazing ecosystem use becomes more intensive, there will be a concomitant demand for rapid, thorough, and quantitative analysis of management records, condition and trend determination, and evaluation of alternative improvement, manipulation, and management practices. This will require increased incorporation of information concerning alternative uses of grazing ecosystems. The examination and evaluation of these various kinds of data and information require greatly changed and improved information processing and analysis systems. Thus, adequate development of such systems and the training of resource managers in their use can lead to current and efficient management of grazing ecosystems based on the newest knowledge.

MAGNITUDE OF POTENTIAL BENEFITS: Present research suggests that improved range management procedures may greatly increase productivity. However, with continued new knowledge about alternative uses of rangeland ecosystems, adequate procedures for updating management knowledge, for optimizing on alternative decisions, and for accounting for uncertainties involved in management, this increase could be much greater.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
4	7

TITLE: Noninsecticidal and integrated methods of controlling insects. RPA 207-A

SITUATION: Noninsecticidal and integrated methods of insect control are especially pertinent to forage crops which usually have low acre values. With increasing levels of resistance to insecticides developing in insect populations, relatively high costs of chemical control, and the threat of residue problems in meat and milk products, alternative methods of control must be sought. Such methods also would avoid the undesirable effects of pesticides on wildlife, beneficial insects, and the increasing concern over environmental pollution. In addition, they would be less likely to interfere with delicate ecological balances of many grasslands. There is a challenge and an opportunity to develop economical control approaches by noninsecticidal methods that will maintain pest populations below the level of economic injury. Noninsecticidal control might involve the use of one or more of such methods as resistant or partially resistant varieties, cultural practices such as time of harvest, flaming, and removal of plant residues, biological control by predators, parasites, pathogens, sterilization, etc. Not all pest problems are amenable to noninsecticidal approaches, and this situation should be recognized. But many avenues exist for reducing the need for use of insecticides by proper use of integrated noninsecticidal control measures.

OBJECTIVE: To develop economical noninsecticidal pest control approaches for forage, pasture, and range.

RESEARCH APPROACHES:

A. Development of insect-resistant varieties of forage crops.

B. Determine nature of insect-resistance in host plant.

C. Establish biological control organisms as self perpetuating control agents in the environment.

D. Develop mass rearing and release techniques for beneficial insects for controlling injurious insects.

E. Explore possibilities of insect control by irradiation, chemosterilants, pheromones, and other physiological methods.

F. Determine effects of cultural practices and environmental manipulation techniques.

G. Conduct ecologic studies to determine the potential threat of present low populations of insects and mites.

H. Assess value of various combinations of methods in controlling insects below levels of economic injury.

CHARACTER OF POTENTIAL BENEFITS: Benefits expected to accrue from this research include reduction in use of insecticides and adjunct dangers to man and his environment, reduced costs of production of forages, and more efficient and permanent insect control.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
34	44

TITLE: Biology and identification of insects attacking forages. RPA 207-B

SITUATION: A knowledge of the identification, biology, life history, and ecology of insect pests is essential to establishment of control practices. Insect identification (taxonomy) is fundamental to basic and applied entomological research. An understanding of the interrelationships between a given insect and its ecosystem establishes the population regulation factors, causes of population outbreaks and, in relation to man's efforts, possible approaches to explore in imposing regulatory factors on the pest population. All control approaches (biological, chemical, integrated, cultural, etc.) must have a foundation of biological data to be used more effectively. The role insects play in the production of forages, definitive data on the population densities causing economic injury, and the most vulnerable stage of development for control can only be approached through biological studies. In general, these interrelationships are better understood on forages and pasture crops than they are on range plants and the complex of insects present in the geographically diverse range land areas. This type of research is of a continuing nature because of the changes in agricultural practices, the introduction of new crops, the introduction of insects from abroad and other geographical areas, and the adaptive patterns of insects.

OBJECTIVE: To study the identification, biology, life history, and ecology of insects attacking forage, range, and pasture lands as a foundation for control practices.

RESEARCH APPROACHES:

A. Study the biology, life history, and ecology of insects under field and controlled conditions.

B. Determine the role insects play in the production of forage, range, and pasture crops.

C. Establish economic threshold levels and economic injury levels for harmful insects.

D. Determine population regulation factors within the ecosystem and the developmental stage most vulnerable to applied control practices.

E. Conduct taxonomic studies of all developmental stages of insects as a foundation for insect identification procedures.

F. Determine effects of environmental factors such as photoperiod, light quality and intensity, temperature and moisture on insect populations, and susceptibility to control.

G. Investigate potentials of sex attractants and other similar compounds as tools in insect control.

CHARACTER OF POTENTIAL BENEFITS: Provide the biological and ecological information necessary to initiate control investigations.

RECOMMENDED RESEARCH EFFORTS:

TF Program Recommendations

1972	1977
21	26

TITLE: Insecticidal control of insects. RPA 207-C

SITUATION: In the foreseeable future man will rely on insecticides to solve many of the injurious insect problems. Insecticidal control is more common in the cultivated forages than it is on rangelands. The emphasis, however, should be away from the pesticides which persist in the environment and toward utilization of short-lived, selective, and biodegradable compounds. Precise information on economic injury levels, particularly in forage crops in which some insect injury is tolerated, will contribute significantly to more intelligent pesticide usage. Because of tolerance restrictions on pesticide residues in dairy products and animal tissue, as well as the vast acreages of rangelands that are wildlife habitats, the use of insecticides has many limitations. Since range and pasture lands are perennial in nature, they provide hosts and habitats for populations of beneficial insects (e.g., those useful in biological control of injurious insects and weeds), and insecticidal approaches must be sensitive to conserving these natural control agents. In general, it is not practical to treat the large areas involved with selective methods of application.

OBJECTIVE: To establish economical, feasible, and safe chemical control practices that protect beneficial insects and wildlife and minimize residues and environmental contamination.

RESEARCH APPROACHES:

A. Establish safe, economical chemical control practices for insects attacking forage, range, and pasture crops.

B. Evaluate chemicals (insecticides, chemosterilants, attractants, repellents, etc.) for their effect on injurious insects, beneficial insects, and wildlife, and determine their persistence in the environment.

C. Explore the use of various chemicals, methods of application, and timing of application to reduce the pesticide residue hazards in forages.

CHARACTER OF POTENTIAL BENEFITS: Reduce the injury from insects through chemical control without undesirable effects on forages and the environment.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
24	28

TITLE: Etiology of forage plant diseases. RPA 208-A

SITUATION: Losses due to diseases of forage crops are estimated to be about 700 to 900 million dollars annually. The losses may range from slight to complete destruction depending on the region, crop, and season. Many different pathogens are involved and all parts of the plants are subject to attack. Among factors limiting maximum production by forage species are diseases caused by soil-borne pathogens. Oftentimes problems of this type are complicated by the fact that more than one pathogen is involved. In addition, a succession of different pathogens may attack roots of susceptible species.

Leaf diseases are common in both legumes and grasses and include the bacterial blights, downy and powdery mildews, tar spot, Helminthosporium leaf blights, leaf scald, Stagonospora leaf spot, Septoria leaf blotch, spring and summer black stem, and Pseudopeziza leaf spot of alfalfa.

Grass establishment has been a problem for many years. Usually fewer than 10% of the seeds sown produce surviving seedlings. Seed-attacking fungus either kills the seedling or weakens the developing plant so that it is unable to survive adverse conditions. Certain viruses are prevalent in both legumes and grasses, and for some it is apparent that the virus has a profound impact on growth and development with long-range impact on stand maintenance. Infected plants are often unable to survive winter injury or prolonged periods of drought when they are infected by certain pathogenic agents. The causal agents for some of the forage crop diseases and the methods of controlling them are not known.

Information on life histories of pathogens as they relate to forage diseases is essential for an efficient control program. Although the life cycles of many of the pathogens are known, knowledge of the taxonomy, ecology, genetics, physiology or modes of pathogenesis of many pathogens is inadequate to provide a sound base for developing effective control measures. Furthermore, detailed information concerning the effects of environment on disease development in forage crops is lacking; thus, it is almost impossible to create artificial epiphytotics of some diseases for effective screening of breeding material in the search for resistant germ plasm. Work has been done with the more intensively grown forage crops, such as alfalfa and red clover, to indicate that artificial epiphytotics can be induced with some pathogens.

OBJECTIVE: To gain understanding of the pathogens of forage crops, the factors influencing disease development, and the losses produced by diseases.

RESEARCH APPROACHES:

A. Identify the pathogens, determine their host ranges, and study their physiology, ecology, and genetics.

B. Determine the effect of environment on disease development and determine those factors that influence epiphytotics through effects on the host and the parasite.

C. Develop effective methods for creating artificial epiphytotics in experimental plots or under greenhouse conditions for evaluation of resistance.

D. Study the means of dissemination of pathogens in association with seeds, plant parts, or insects.

E. Initiate forage physiology studies to determine the nature of pathogenesis and physiological changes in the host resulting from infection by various pathogens.

F. Determine the causal agents of diseases of which the inciting agent is not known, such as internal breakdown of red clover.

G. Assess the extent of injury caused by nematodes to forage legumes and grasses.

H. Determine the effect of viruses and other diseases on forage crop root rots.

CHARACTER OF POTENTIAL BENEFITS: Yield and quality of hay and pasture will be improved with the use of disease-resistant varieties of forage legumes and grasses. Disease-resistant varieties can be developed more effectively when specific causes of disease and conditions under which they develop are understood. Information is needed to facilitate selection of plants resistant to prevalent and destructive pathogens. Furthermore, knowledge of the ecology and epidemiology of major pathogens will provide the basis for the development of improved management practices.

MAGNITUDE OF POTENTIAL BENEFITS: The magnitude of potential benefits cannot be directly assessed, but is related to increasing yields through breeding and other control procedures. Diseases cause major losses in production annually, and the development of resistant varieties and improved cultural practices could reduce this loss to less than one-hundred million dollars a year. Forage legumes, in particular, have an estimated value of several billion dollars a year. It is estimated that diseases cause losses of at least 10% and possibly 20% annually.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
13	17

TITLE: Control of disease by development of disease-resistant varieties by breeding and selection. RPA 208-B

SITUATION: Plant pathogens, including bacteria, fungi, viruses, and nematodes, which attack forage legumes and grasses, are likely to impair stand establishment, reduce the longevity of perennial species, seriously affect forage quality, and severely reduce forage and/or seed yield. Because of the relatively low value per acre and extensive acreage involved, disease resistance is the most feasible procedure for control of forage crop diseases at the present time. Progress has been made in incorporating resistance to bacterial wilt and the stem nematode in alfalfa, to powdery mildew in red clover, and to leaf blight and leaf rust in some grasses. Genetic resistance, identified for many diseases of forage crops, is not being incorporated into new varieties rapidly enough. Practically nothing is known about the nature of resistance to diseases in forage crops.

OBJECTIVE: To identify sources of resistance to pathogens of forage crops, to determine mode of inheritance of resistance, and to transfer resistance to productive, well-adapted varieties.

RESEARCH APPROACHES:

A. Evaluate germ plasm for reaction to diseases.

B. Study inheritance of host reaction to pathogens.

C. Conduct breeding programs to transfer multiple disease resistance to productive varieties.

D. Determine the mechanisms of resistance in forages to pathogens, especially biochemical and physiological interactions in host-pathogen relationships.

CHARACTER OF POTENTIAL BENEFITS: Hazards of production will be reduced; seed and forage yield, quality, and persistence will be increased.

MAGNITUDE OF POTENTIAL BENEFITS: The success of a forage species, in many instances, will depend on the success of plant pathologists and plant breeders in developing disease-resistant varieties. Pesticides are not practical for application to many forages. Diseases cause an estimated loss of about 700 to 900 million dollars annually. If resistant varieties were available, much of this loss could be prevented.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
20	29

TITLE: Role of insects in the transmission of viruses and other pathogens. RPA 208-C

SITUATION: The importance of insects in the transmission of certain types of pathogens is well established. Little has been done with insect transmission of pathogens of forage crops. Insects are important in the transmission of viruses. A 23 to 55% reduction from virus infection when symptoms may not be readily apparent or are masked has been demonstrated. Incidence of virus infection increases with age of stand. A 3-year-old field of alfalfa can have 25% or more virus-infected plants. Investigations should be expanded to determine the relationship between insects and the development of forage crop diseases.

OBJECTIVE: To determine the relationships between insects and the development of certain diseases of forage crops, and to use this information in developing control measures.

RESEARCH APPROACHES:

A. Determine the transmission of viruses by means of leafhoppers and aphids as well as other insects.

B. Determine the virus movement and increase within the vector.

C. Determine the importance of insects and viruses in the development of root rots.

D. Determine the importance of insect populations on the spread and development of epidemics of diseases, especially virus diseases.

E. Determine the importance of insect control on disease development.

CHARACTER OF POTENTIAL BENEFITS: Increased persistence, higher forage and seed yields, and improved forage and seed quality.

MAGNITUDE OF POTENTIAL BENEFITS: This is difficult to quantify because of the lack of information.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
4	6

TITLE: Pesticides and management in controlling diseases and nematodes. RPA 208-D

SITUATION: Forage crops are grown extensively and resistant varieties are not always available. Investigations to develop alternative control measures should be emphasized. Control of foliage diseases appears to be feasible because of recent developments in the control of leaf diseases of cereal crops with low volume spraying of fungicides. Within the last 3 years systemic fungicides have been developed and are being used by farmers to control certain field crop diseases. This has great potential with forage crops, particularly in controlling diseases of seed crops where the forage is not used for animal feed. Application of fungicides and early harvesting might achieve significant reduction in losses due to foliage disease. Some success has been achieved by burning crop residues. This is particularly true for seed crops, resulting in control of several fungal diseases as well as nematodes. Because of undesirable air pollution, alternative procedures and additional research on burning is needed. Many workers rate root rots as being among the more important diseases of forage crops, yet little progress has been made in development of resistant varieties. Development of varieties resistant to alfalfa wilt is a notable exception. It is possible that better management practices can be developed and economically suitable pesticides discovered for satisfactory control of the root rots. Viruses and parasitic nematodes cause stand and yield reduction of many forages. A systematic search for management practices and pesticides for controlling nematodes and viruses will be desirable. Less expensive and more effective nematocides need to be developed. They are likely to find their greatest usage on turfgrass.

OBJECTIVE: To study the use of management practices, including the use of pesticides for the reduction of losses due to diseases of forage crops.

RESEARCH APPROACHES:

A. Determine how to control foliage diseases of forage crops with fungicides and other pesticides.

B. Study the effects of management systems on development of foliage and root diseases and on preventing disease losses.

C. Determine crops and weeds which may serve as alternate hosts for forage crop pathogens.

D. Test chemical agents for systemic or localized control of diseases and develop techniques for the effective use of such agents.

CHARACTER OF POTENTIAL BENEFITS: Disease incidence and severity would be significantly reduced, and thus the quality and quantity of forage and seed would be increased.

MAGNITUDE OF POTENTIAL BENEFITS: It is not possible to accurately quantify the benefits because there is little information available. Studies in small plots indicate that yield increases of forage may be as much as a ton per acre when alfalfa is sprayed with fungicides. Blind seed disease and ergot control by post-harvest burning of straw in grass seed fields is estimated to save farmers $20 million annually. Applications of 1 to 3 sprays of nickel sulfate-maneb fungicide to Kentucky bluegrass seed fields has virtually eliminated former losses of 50 to 100%.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
5	8

TITLE: Identification and control of foreign diseases that may damage forage crops. RPA 208-E

SITUATION: Certain plant pathogens, known to attack forage crops in other parts of the world, have not been identified as occurring in the U.S. An example of this is the Verticillium wilt of alfalfa. The strain that attacks alfalfa in Europe is devastating. A leaf rust occurs widely in parts of Europe on sweet blue lupines. So far this disease has not been found in the Southeastern United States where lupines are grown. There is always the danger of importing new viruses into the U.S. in or on seeds. International trade in seeds increases the possibility of the introduction of foreign pathogens into the United States. The reaction of U.S. forage crops to these pathogens should be determined.

OBJECTIVE: To determine the reaction of germ plasm of forage crops to foreign diseases, and to better understand the potential damage that might result if the pathogens were introduced.

RESEARCH APPROACHES:

A. Identify foreign diseases of potential importance.

B. Screen U.S. varieties of forage crops for reaction to pathogens in areas where the diseases are found. An alternative would be the establishment of an off-shore isolation facility where forage crops could be tested for resistance to foreign diseases.

C. Study the nature of the disease and its incidence in the foreign area.

D. Initiate breeding programs in cooperation with foreign scientists to develop resistant lines for U.S. areas where the diseases could be a problem.

CHARACTER OF POTENTIAL BENEFITS: Minimize destructive effects upon U.S. forage crop production if foreign pathogens are introduced.

MAGNITUDE OF POTENTIAL BENEFITS: It is not possible to quantify the benefits of protection against new diseases. However, introduction of a disease such as Verticillium wilt of alfalfa could cause a loss of millions of dollars a year.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
2	2

TITLE: Relationship of disease in forage crops to quality. RPA 208-F

SITUATION: Forage crops are generally harvested by grazing or conserved as hay or silage. The plants are often diseased and the quality of the feed may be greatly reduced. Work done during the last years at South Dakota indicates that alfalfa infected with certain foliar diseases contains more coumestrol than does healthy alfalfa. Foliar pathogens often cause premature death of foliage, which undoubtedly affects forage quality. In addition, some fungi produce toxic metabolites that may affect animals consuming the diseased forage. A great deal of effort should be devoted to learning how microorganisms decrease the quality of hay and how low quality feed affects animals.

Growth of fungi in forages has resulted in the accumulation of mycotoxins which are extremely harmful to animals consuming infested forage. Rhizoctonia leguminicola, causal agent of black patch of red clover, has been shown to produce an alkaloid which causes excessive salivation in dairy and beef cattle.

OBJECTIVE: To determine the relationship of healthy and diseased forage crops to forage quality, and the effects of differences on animal production.

RESEARCH APPROACHES:

A. Determine chemical differences in hay and silage produced from healthy and diseased forage crops.

B. Determine the differences in animal performance resulting from feeding diseased and healthy forage crops as hay and silage.

C. Evaluate the possible role of mycotoxins as causal agents for certain animal disorders commonly associated with the feeding of grasses.

D. Investigate procedures in the management and handling of hay and silage which may influence the quality and the possible development of those fungi that produce mycotoxins injurious to animals.

CHARACTER OF POTENTIAL BENEFITS: Reduced losses in livestock production from consumption of low quality forage.

MAGNITUDE OF POTENTIAL BENEFITS: It is difficult to quantify, but a conservative estimate would involve millions of dollars annually.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
6	8

TITLE: Herbicide specificity, selectivity, and interaction with other chemicals in relation to establishment and production. RPA 209-A

SITUATION: Brush infests 320 million acres of the billion acres of land grazed in continental United States. In addition, poisonous and other herbaceous weeds are found in all grazing lands. They are most abundant on ranges in poor condition. Brush, weed grasses, and other herbaceous weeds displace valuable forage species and reduce production and quality of forage. Some cause poisoning and physical injury to livestock and reduce the quality of animal products. Also, weeds impair establishment of new forage seedings.

Weed control in forage crops and pastures is characterized by special problems. The forage is frequently composed of many plant species. These consist of several species of grasses intermixed with other desirable species, such as legumes in pastures of humid regions and browse species in rangelands. The forage species are interspersed with undesirable woody plants and other weeds on grazing lands. Selective elimination of the undesirable species is a prerequisite in upgrading range vegetation. Subsequently, competition from desirable vegetation is needed to minimize reinvasion. Herbicides with properties broad enough to kill many types of weeds frequently eliminate some of the desirable forage species as well. Some weeds are resistant to herbicides, and these tend to spread when the herbicide treatments kill other competitive weeds.

The complexity of the weed control problem is indicated by a survey in 1965. There were 105 weed species on rangelands and 147 weed species on hay and pasture lands listed among the 5 most important weeds in these situations in the various States included in responses to the survey. Control methods must be developed for the individual species. Information is largely lacking as to why a herbicide will kill one plant but not another. In the foreseeable future, introduction and evaluation of new herbicides and mixtures of herbicides having specific herbicidal properties will provide the primary source of new and improved methods of weed control.

OBJECTIVE: To devise and identify methods of killing specific weeds, determine the minimum effective treatment levels of herbicides, and develop combination measures for more efficient weed control.

RESEARCH APPROACHES:

A. Evaluate new herbicides for controlling specific woody and herbaceous weeds in forage and on grazing lands in the geographic area where the weeds are problems.

B. Determine minimum rate, proper timing of treatments, and conditions contributing to efficient action of herbicides on specific weeds.

C. Evaluate promising herbicides for selectively controlling weeds in typical weed-forage situations. Develop reliable practices for use in grazing management systems.

D. Develop combinations of herbicides that will control weed species that occur in grazing areas.

CHARACTER OF POTENTIAL BENEFITS: Following application of effective brush control measures as much as eightfold increase in forage production has resulted where residual grasses are present. Control of brush facilitates good management of livestock by allowing proper herding of cattle, regular inspection and treatment for disease and insect disorders, and orderly culling and marketing. Control of weeds in new seedings increases the chances for successful establishment of vigorous stands of forage species. Control of poisonous species reduces livestock deaths and unthriftiness due to non-fatal poisoning. In addition, proper weed and brush control allows more timely and efficient use of the infested range areas where livestock would otherwise be excluded, at least for a part of the grazing season.

MAGNITUDE OF POTENTIAL BENEFITS: The estimated annual loss resulting from brush and weeds on grazing land is $633 million. This is based on an estimated loss in yield of forage of about 13% in the Western half of the United States and 20% in the Eastern. Added to the above loss is the present estimated cost of controlling brush and weeds on grazing lands of $365 million. Our research will not greatly reduce this latter because there will be continuing need for maintenance weed and brush control to deal with re-infestation problems. The potential benefit of about $600 million annually will be from increased yield of forage on grazing lands where weeds and brush are controlled. To accomplish this will require the balanced research program outlined under 209-A, B, C, D, E, F, and G. (See also noxious range plant control, RPA 112-G. Some research under 209 will be in cooperation with studies conducted under 112-G.)

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
6	7

TITLE: Application techniques to improve herbicide performance. RPA 209-B

SITUATION: Drift of herbicides to nontarget sites not only injures vegetation in adjoining areas but may reduce the amount of herbicide applied to weeds. Some herbicides are volatile and hence may disappear too rapidly or injure nearby sensitive crops. Some are nonselective but might be useful if applied as directed sprays or as preplanting treatments. New techniques for incorporating herbicides in the soil may improve performance. Use of adjuvants and improved carriers may enhance absorption by plants. Improved application techniques are becoming available, and they should be evaluated.

OBJECTIVE: To improve weed control on grazing lands by studies on various techniques of applying herbicides.

RESEARCH APPROACHES:

A. Determine the most effective means of applying volatile and nonvolatile herbicides (incorporation at planting, injection and directed spray devices, equipment and formulations minimizing fine droplet formation, etc.). This would include studies of chemical additives and slow-evaporating carriers.

B. Develop application techniques for nonselective herbicides in forage seedings and individual plant treatments. These will include preplanting treatments, chemical fallow, and various directional devices to minimize forage injury.

C. Cooperative projects will include work in RPA 307 and 308.

CHARACTER OF POTENTIAL BENEFITS: Increase the effectiveness of herbicides, and provide new herbicides for controlling weeds on grazing lands through improvements in techniques. Decrease the hazard of using herbicides near susceptible plants which may allow use of the herbicide during the most favorable season. Increase the amount of herbicide at active sites in weed species.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefit is included in 209-A.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
4	5

TITLE: Life history and ecology of specific weeds in forage. RPA 209-C

SITUATION: Only superficial information exists on many species of unwanted herbaceous and woody plants that are problems on grazing lands.

The number of important species far exceeds the 147 weed species reported from hay and pasture lands. For many of these species little information is available on their life history, including phenology as related to weedy character of the species, longevity of seeds in soil and nature of dormancy, presence of dormant buds and how dormancy can be alleviated, and other growth characteristics that can be utilized in developing control methods.

OBJECTIVE: Determine the life history and ecology of herbaceous and woody weeds that are a problem in grazing lands.

RESEARCH APPROACHES:

A. Conduct studies of life cycles of weeds, the chemical and physiological phenomena governing seed and bud dormancy, and the germination of weed and brush species to find the most vulnerable point for control by cultural, biological, and chemical means.

B. Determine the impact of environment, including associated vegetation, on the reproduction and spread of the weed, the stages of its life cycle when the weed is most susceptible to methods of control and which limit its range of distribution. Determine what manipulations of environment can be used to advantage in control programs.

CHARACTER OF POTENTIAL BENEFITS: Detailed information on life history and ecology of individual weed species provides a firm and essential foundation upon which methods of controlling the weed species can be developed. Such information enables the weed scientist to devise effective control measures and reduces the amount of empirical research required.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefits is included in 209-A.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
5	6

TITLE: Residues in soils and plants in relation to forage production. RPA 209-D

SITUATION: Residues in soils and plants result from some herbicidal treatments. Some of these are persistent in the soil and interfere with establishment of new seedings of forage crops. Herbicides may be found in forage for a time after treatment. These residues may prevent approval of registration applications and limit the uses that may be made of the herbicide. We need to learn more about the fate of herbicides in plants and soils and about modifications of formulations or other treatments that may cause rapid disappearance of the residues.

OBJECTIVE: To determine fate of herbicides in plants and soils and means of altering the rate of disappearance.

RESEARCH APPROACHES:

A. Treatments will be made on soils under geographic and climatic conditions typical of sites where the weeds are common problems.

B. Determine the persistence and effect of residues in soil on seedling establishment and on forage production.

C. Obtain from field samples information on the fate of herbicides in soil and in plants.

D. Correlate field results with those obtained in laboratory and greenhouse studies where conditions are controlled.

CHARACTER OF POTENTIAL BENEFITS: Responses of plants to residues in the soil, the fate of herbicides in soils and plants, and the amount of residue in the plant may determine if a herbicide practice can be recommended for weed control on grazing lands. These are vitally important studies in the overall research program on methods of weed control.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefits is included in 209-A.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
3	3

TITLE: Mechanism of action of herbicides. RPA 209-E

SITUATION: The mechanism of action of few herbicides has been fully investigated. Considerable information on response of metabolic systems of plants to some of the more important herbicides has been acquired. However, the exact site(s) of action has been determined for very few.

We need to examine plants treated with chosen herbicides for cytological, histological, anatomical, and morphological changes at all levels of magnification. The potential for the structural approach to provide clues to the mode of action of herbicides is very high. We know that many weeds cannot be killed by present herbicides, and information is lacking as to why a herbicide will kill one plant but not another. Movement and accumulation of herbicides in plants, soils, and water are not understood. A more exact knowledge of the mechanism involved in conditioning leaf, stem, and root surfaces for efficient penetration by herbicides and their movement after penetration is needed to provide a sound basis for the development of practical and reliable procedures for using herbicides to control weeds.

OBJECTIVE: To understand the mechanism of action of herbicides physiologically, cytologically, histologically, anatomically, and morphologically, and to determine the conditions and characteristics contributing to the variations in the magnitude of response of plants.

RESEARCH APPROACHES:

A. Determine the effect of herbicides on metabolic systems and activities of higher plants and unicellular organisms at the macro- and microcellular level.

B. Determine how the herbicides interfere with the role of enzymes in chemical processes in cells.

C. Investigate the effect of herbicides on cytological and anatomical abnormalities and their consequence to the plant's life processes.

D. Determine the effect of plant constituents on herbicide selectivity among plant species.

E. Investigate barriers to absorption and translocation of herbicides in plants and how they may be overcome to enhance effectiveness of herbicides.

CHARACTER OF POTENTIAL BENEFITS: More effective and reliable uses of herbicides can be planned if knowledge is available on the physiological, anatomical, and chemical response of plants to them. This information also will provide clues useful for development of new and more effective herbicides.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefits is included under 209-A.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
3	3

TITLE: Integration of cultural, chemical, and management systems of weed control. RPA 209-F

SITUATION: The invasion of weeds and brush, and conversely their control, results from the interplay of myriad environment, soil, plant, and climatic variables.

Weeds infest grazing lands across many climatic conditions ranging from arid to humid, on soils varying from sand to clay, and in vegetative types from desert shrub to savannah to tall grass prairie. The selective control of weeds must be adapted to the situation and site where weeds are normally a problem. Advantage can be taken of agronomic practices favorable to vigorous growth of grasses and legumes in pastures and ranges. Competition of vigorous forage species contributes to and helps to hold gains made by the control method. The control method may need only to tip the balance in favor of forage crops. Choice of method, time and method of treatment, and cost of control must be adapted to a usable grazing and livestock system. At present, research on the integration of new methods of weed control into existing grazing systems is mostly inadequate and too often nonexistent. Research of this nature can best be conducted by weed scientists working cooperatively with research personnel trained in many disciplines.

The weed and brush problem is so complex that its solution requires a concerted hard-hitting program to remove the weeds and brush efficiently, reestablish forage plants, and develop plant, soil, water, livestock, and wildlife management practices to maintain high range productivity.

OBJECTIVE: To integrate methods of controlling weeds into forage and grazing management systems to provide reliable and practical programs.

RESEARCH APPROACHES:

A. Evaluate the interactions of promising methods of controlling weeds and brush with existing systems of grazing and management of pastures and rangelands.

B. In cooperation with forage management and seeding specialists, animal scientists, and other appropriate researchers, devise modifications in existing management practices that will contribute to the control of weeds and brush and impede their reinvasion of the grazing lands while, at the same time, improving productive capacity of the area.

C. Explore methods of controlling weeds and brush, the proper time and method of treatment, and their relative impact on forage species.

D. Determine the costs and benefits of the most promising integrated systems of brush and weed control on grazing lands.

CHARACTER OF POTENTIAL BENEFITS: Sound and reliable practices for controlling weeds and brush will be integrated into efficient production systems. These will yield maximum benefits by insuring economical productive capacity from forage crops and pastures.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefits is included under 209-A.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
6	7

TITLE: Weed control by biological agents other than insects. RPA 209-G

SITUATION: Many species of weeds and brush cover extensive areas. Many species have little or no economic value nor have they closely related species of economic value. These are prime subjects for the use of plant diseases or other organisms to reduce the vigor and stand of the weed species. This will provide opportunity for more vigorous forage species to displace them. The potential effectiveness of plant diseases in killing plant species is indicated by the devastation of the American chestnut in eastern forests by the accidental introduction from Asia of the fungus chestnut blight, Endothia parasitica. Almost equally devastating is the fungus known as Dutch elm disease, Ceratocystis ulmi, inadvertently introduced in the U.S. from Holland. Many weed species such as halogeton, Halogeton glomeratus (M. Bieb) C. A. Mey., occur on rangelands of low productive capacity that economically will not support recurring costs for controlling weeds. Introduction of biological agents that would spread naturally and exert continuing injurious effects on the weed could "tip the balance" in favor of forage species. Under biological control, the weed might exist in a subdued state and cause little reduction in yield and be a minimal risk as a poisonous plant. Finding, evaluating, and introducing such biological agents is time consuming.

OBJECTIVE: To discover, evaluate, and introduce biological agents, other than insects, for selective control of weed and brush species.

RESEARCH APPROACHES:

A. Explore the native habitats of weed species and their closely related species to collect candidate plant diseases or other biological organisms.

B. Evaluate biological agents for effectiveness on target weeds and for safety on crops in the U.S.

C. Develop information, based on many selected species, required for consideration in obtaining permission to introduce biological agents into the U.S.

D. Develop methods of using candidate organisms for weed control.

E. Coordinate work with entomology, mycology, and epidemiology investigations.

CHARACTER OF POTENTIAL BENEFITS: Development of a method of control that will be self-sustaining at no continuing cost for treatment of individual important species. Such method would be particularly advantageous and probably the only practical method for controlling weeds on grazing lands of low productive capacity.

MAGNITUDE OF POTENTIAL BENEFITS: Magnitude of potential benefits is included under 209-A.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
6	7

TITLE: Improved breeding methods, genetics, and cytogenetics of forage grasses and legumes. RPA 307-A

SITUATION: Methods for accomplishing breeding research with the complex forage species can be improved. Genetic variability presently available within forage grass and legume species will be rapidly exhausted by the intensive breeding efforts now being made by commercial seed companies as well as experiment station and Federal plant breeders. New sources of genetic diversity will be needed if continued progress through breeding is to be made. An understanding of the genetic basis for the extreme sensitivity of some forage species to inbreeding depression in relation to autopolyploidy might provide significant new insight into the nature and more efficient utilization of heterosis. The usefulness of inbreeding in parent clone development, the performance of obligate and preferential hybrids and synthetics, and the relationship between internal heterogeneity and adaptation and performance should be investigated. Additional research, including cytogenetics, on interspecies and intergeneric crosses, especially among the cool-season grasses, is needed. Studies of methods for greater use of heterosis, effectiveness of hybridization techniques, use of various kinds of progeny for evaluation of selections, genetic gain through recurrent selection, and performance of-hybrids and synthetics through several generations are imperative. Variety synthesis investigations should be continued to insure maximum efficiency, speed, and productivity in forage crop breeding. There is a need for greater research effort in the isolation, characterization, and development of male-sterile lines, fertility restorers, and genetic marker stocks in forage species. Male-sterile lines and restorers offer a logical approach to the production of hybrid populations. Genetic stocks would be useful in many areas of forage crop breeding, including studies of the genetic and physiological basis of self-incompatibility, the development of alternate methods of inbreeding through diploidization, establishing spatial isolation requirements, determining pollination patterns, and evaluating randomness of pollination in a polycross. The relation of gametic and seedling traits to mature plant characteristics should be investigated. Many pleiotropic characters may exist which could be of value to plant breeders. A better understanding of the effects of natural and artificial selection pressures will assist in developing more effective breeding methods. Further studies on the origin and inheritance of apomixis are a requisite to efficient utilization of this phenomenon in breeding programs.

OBJECTIVE: To improve breeding methods through genetic and cytogenetic investigations, population studies, and the development of superior breeding techniques.

RESEARCH APPROACHES:

A. Characterize available germ plasm, including introductions, interspecific and intergeneric progenies, and hybrid and synthetic

populations, in search for new sources of genetic diversity. Evaluate promising new forage species that are not included in current research programs.

B. Clarify the taxonomic relationships of forage grasses and legumes so that potentially useful breeding material can be more effectively and systematically utilized.

C. Isolate, characterize, and develop stable male-sterile lines, fertility restorers, and genetic marker stocks. Investigate further the genetic, cytological, and biochemical aspects associated with male-sterility.

D. Study and develop breeding procedures for improving forage crops.

E. Determine the role of inbreeding and the most effective system for utilizing heterosis in polyploid complexes.

F. Study the genetic structure, variability, and patterns of inheritance in forage species.

G. Employ in vitro pollen tube growth studies to explore the genetics and physiology of self-incompatibility in forage legumes.

H. Determine the origin and inheritance of apomixis.

I. Conduct genetic and cytogenetic research on interspecific and intergeneric hybridization.

CHARACTER OF POTENTIAL BENEFITS: Improvement in genetic potential for many characteristics. The success of RPA 307-B, -C, and -F will be enhanced by findings in RPA 307-A.

MAGNITUDE OF POTENTIAL BENEFITS: They cannot be quantified specifically, but great advances in the development of forage varieties, especially productive commercial hybrids, will arise from these basic genetic studies. Improved breeding methods are vital to the successful development of superior varieties.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
50	65

TITLE: Breeding for yield of forage and seed, seed quality, and seedling vigor and tolerance to environmental hazards. RPA 307-B

SITUATION: Relatively low average acre yields of feed units produced by perennial forages is rapidly becoming a critical factor in the traditional role of forages as the base for economic livestock production. Higher yields are necessary to hold down production costs. Low yields result partly from failure to utilize full genetic potential and partly from low production inputs including relegation of forages to poorer soils. Breeding has been effective in increasing yield of many annual forages, but the level of achievement with most perennial polyploid forages has been much less. Considerable genetic potential exists for increasing biological efficiency of all forages, but new approaches are required to increase efficacy of selection for both seed and forage yield. Perennial forages occupy land areas year-round and thus are subjected to more environmental hazards such as drought and temperature extremes than are annuals. Further, forages often are seeded on sites where environmental hazards are especially severe, to serve the dual purposes of forage production and soil conservation. We need to combine increased genetic yield potential with increased seedling vigor and, where necessary, tolerance to environmental hazards. Good seed production potential is necessary for any variety, except those propagated asexually, to enter commercial channels.

OBJECTIVE: To develop varieties of annual and perennial forages possessing high genetic potential for yield of forage and seed, greater seedling vigor, and tolerance to existing environmental hazards.

RESEARCH APPROACHES:

A. Develop rapid, highly repeatable techniques for evaluation of large individual plant populations for components of biological efficiency.

B. Establish whether certain morphological or anatomical characteristics are associated with high photosynthetic efficiency.

C. Determine heritability of the components of biological efficiency.

D. Isolate germ plasm that will increase the application of systems for utilizing heterosis for yield and quality in forage breeding.

E. Improve techniques for screening for tolerance to various environmental hazards such as drought, temperature extremes, and saline soils.

F. Develop germ plasm and varieties with greater usefulness on difficult sites for soil stabilization and forage production.

G. Develop varieties with high yield potential under high management input.

CHARACTER OF POTENTIAL BENEFITS: Increased acre yields of low cost feed units from forages would contribute greatly to providing a sound and permanent base for the Nation's livestock industries and remove the uncertainty of future human competition for cereal grains. Higher forage acre yields will help to meet the increasing demand for beef and dairy products and to maintain relatively stable prices. Availability of improved forage species for use on difficult sites would combine soil stabilization and decreased water pollution with forage production, water conservation, wildlife habitat, and recreational and natural beauty values.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
70	80

TITLE: Breeding and management for improved forage quality. RPA 307-C

SITUATION: Forage quality is that characteristic which expresses the relationship of nutritive value to animal performance and production. It is influenced by many factors, primarily chemical, which have plus and minus effects on acceptability, digestibility, growth, and reproductive processes of the animal. The extent to which forages will be used in livestock production will be determined by quality and cost per unit of digestible nutrient. The formula feed industry needs forage products which are superior in specific constituents than can now be purchased in the market. New harvesting and processing systems require varieties with characteristics adapted to the system used. Marketing opportunities for improved and specialized forage products are not limited to animal feed, however. Alfalfa, for example, produces more protein per acre than any other crop and has tremendous potential as a source of proteins for human consumption. Variation associated with some constituents affecting quality of forage has been characterized genetically and statistically. These results were important in making decisions as to whether breeding or cultural procedures should be the research approach used to modify the quality constituents studied. Research on improving forage quality has barely begun.

OBJECTIVE: To improve forage quality by breeding and management, utilizing information on inheritance and biochemical nature of specific traits.

RESEARCH APPROACHES:

A. Characterize the variability associated with each constituent affecting quality in order to determine the relative importance of heredity, environment, and stage of growth.

B. Conduct selection and breeding research to modify the more heritable constituents.

C. Develop management practices as means of modifying and stabilizing constituents which fluctuate greatly with environment or stage of growth.

D. Develop lines or populations with improved quality, combined with multiple disease and insect resistance and greater responsiveness to water, light, and nutrients.

E. Define and characterize factors which limit production of digestible nutrients per unit of land and time.

CHARACTER OF POTENTIAL BENEFITS: Reduced costs in the production of forages for conversion into products needed for animal and human consumption.

MAGNITUDE OF POTENTIAL BENEFITS: An average gain in animal efficiency of only 5% would yield $400 million annually in benefits.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
50	65

TITLE: Seed production of forage grasses and legumes. RPA 307-D

SITUATION: Seed production of forage, pasture, and range plants is uniquely different from cereal fiber and oil crops where seed is a by-product of crop production. Most forage crops are grown for their vegetative features and are harvested and used prior to development of mature seed. Forage seed production is a separate operation with large quantities produced outside the intended area of usage. Seed production of the major forage grasses and legumes has become a specialized farm enterprise concentrated in regions with favorable climates, generally on valuable land well suited to alternative crops. It is important, therefore, that seed supply be coordinated with demand in seed-consuming areas. Increased specialization has placed new demands on efficiency in growing, harvesting, and processing forage seed crops. Critical problems exist in maintaining the productive life of seed fields, in improving seed yields of species and varieties, in providing reasonable isolation, and in establishing seed fields on land where another variety of the same species has been grown for seed. The forage seed industry is under severe pressure from low or erratic seed yields, increased production costs, and in some species from foreign imports. Domestic production of some important species is 10 to 40% below national consumption. Failure to provide for domestic seed needs can be attributed in part to the lack of advanced technology.

OBJECTIVE: To improve the efficiency of forage seed production and assure reliable supplies of high quality seed of improved varieties for domestic and foreign markets.

RESEARCH APPROACHES:

A. Determine the factors limiting pollination in legume seed fields. Study pollen viability and plant attractants, and develop cooperative research to improve bee visitation (see also RPA 307-B) and to evaluate the importance of bee populations and strains (see also RPA 207-B).

B. Characterize seed set and factors limiting seed set of male sterile lines in insect-pollinated legumes.

C. Develop realistic isolation standards to insure satisfactory levels of genetic purity for wind- and insect-pollinated crops.

D. Determine the ecological and physiological factors which result in declining seed yields with increasing age of stand, and develop methods for preventing or reducing this decline.

E. Develop reliable techniques for improving the reliability of seed production trials.

F. Determine the seed production potential and population shifts of domestic and foreign grass and legume varieties. These should include investigations to identify the degree to which specific environmental factors influence genetic shift.

G. Develop new production principles and more efficient cultural practices including seeding dates, rates, and methods, chemical treatments, pesticides, growth regulators, fertilizer practices, reducing losses from shattering, and crop sequence for use under different environmental conditions. Many of these studies will be developed in conjunction with RPAs 207, 208, and 209.

H. Develop alternative to post-harvest burning for control of pests, weeds, and volunteer plants.

I. Develop effective methods for controlling volunteer plants in shifting from old to new varieties of the same species.

J. Investigate the complex physiological and biochemical changes that regulate the transition between developmental stages, including basic studies on growth responses, flowering, seed setting, and maturation as influenced by quantity and quality of light, photoperiod, temperature, soil moisture, humidity, nutrition, and stand density.

K. Investigate the underlying physiological, biochemical, and morphological characteristics of plants that cause hard seed and dormancy.

L. Conduct basic research on the biochemistry and biophysics of seed germination and storage life, and relate this information to management, harvesting, processing, and storage practices and to genetic research on the improvement of seed quality.

M. Develop efficient and reliable chemical and physiological tests for identifying forage varieties.

CHARACTER OF POTENTIAL BENEFITS: Increasing yield and quality of forage seed and improvements in production efficiency will reduce seed costs for improved grass and legume varieties, and help to assure adequate supplies of high quality seed. The competitive position of U.S. seed growers will be improved in both the domestic and foreign market.

MAGNITUDE OF POTENTIAL BENEFITS: Significant research progress could contribute to average gains of from 15 to 25% in production efficiency. At this level, the return to growers would approach $40 million annually.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
40	48

TITLE: Biochemical principles of forage growth. RPA 307-E

SITUATION: Plant growth is the result of numerous biochemical reactions responding to both internal and external forces. These forces, or environmental stresses such as drought, temperature, defoliation, etc., affect the basic biochemical pathways of ribonucleic acid and protein metabolism, nitrogen fixation in legumes, energy utilization, deposition of plant tissues, enzyme systems, and growth regulation.

The definition of these stresses and biochemical reactions and their relation to growth and development is needed to furnish principles that can be used to change plants and design new plants for specific needs. This information is essential to overcome the apparent barriers to efficient gains in forage yield, and especially yield of nutrients per unit area. To date only a limited amount of this information is available for forages.

OBJECTIVE: To establish the interrelationship among biochemical processes, environment, and growth.

RESEARCH APPROACHES:

A. Define effects of temperature and drought on the photosynthetic process, nitrogen metabolism, growth regulation, and survival.

B. Clarify the relationship or translocation to energy accumulation and use.

C. Determine the factors that affect efficiency of energy conversion and the chemical nature and mobilization of energy reserves in growth and development.

D. Define the sequence of growth regulatory processes in plant development including senescence.

E. Determine the variables that control cell division and cell elongation.

F. Determine the variables that control the efficiency of symbiosis of rhizobia and legumes.

CHARACTER OF POTENTIAL BENEFITS: Provide the plant breeder with specific criteria to select for primary components of yield. Provide a sound biologic basis for developing management practices and predicting plant responses in a given environment. Provide the farmer with a wide selection of forage plants that utilize, with maximum efficiency, all environmental resources and genetic potential.

MAGNITUDE OF POTENTIAL BENEFITS: Refer to RPA 307-G.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations	
1972	1977
25	35

TITLE: Management principles of growth and development. RPA 307-F

SITUATION: Sound management is the key to realizing the full yield potential of forage plants and the desired level of production of animal products. Sound management is based on a complete knowledge of plant growth in response to environment. The plant, the animal, and the environment are continually changing. The dynamic interrelationship of all components has not been defined in such a way that a total forage-livestock management system can be designed.

If a farmer is to maintain a high level of forage production, he must continually refine and improve his managerial decisions. This can only be done with a complete set of management guidelines for evaluating alternatives.

OBJECTIVE: Develop sound management practices based on principles of plant responses to environmental factors imposed by nature, by the animal, and by man.

RESEARCH APPROACHES:

A. Establishment:
   1. Develop reliable information for predicting optimum date of planting or replanting.

   2. Characterize environmental factors that influence germination and seedling growth.

   3. Determine the factors involved in inter- and intra-species competition, and develop practices to modify competitive relationships among and within species.

   4. Define factors affecting and develop techniques for improving nodulation of legumes by nitrogen-fixing bacteria.

B. Growth and development:
   1. Determine optimum tillering patterns for pasture- and hay-type forages.

   2. Determine leaf arrangement and morphology for optimum light interception and net photosyntheses of pasture- and hay-type forages.

   3. Define range of adaptability of forages to temperature and moisture.

   4. Define the interrelationship of morphological and anatomical characteristics to physiologic processes.

5. Determine the relationship of growth habit and growth cycle to longevity and survival.

C. Harvesting:
   1. Define growth in response to complete and partial defoliation for pasture- and hay-type forages.

   2. Define optimum defoliation pressure for major forage species environment, and animal response.

   3. Define plant responses to rapid climatological changes as a result of defoliation or meterological events.

CHARACTER OF POTENTIAL BENEFITS: Provide reliable, uniform distribution, and greater yield of quality forage.

MAGNITUDE OF POTENTIAL BENEFITS: Refer to RPA 307-G.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
40	50

TITLE: Develop superior forage use practices. RPA 307-G

SITUATION: Many factors contribute to unprofitable livestock production. Prominent among these are sharp fluctuations in forage quality and quantity and inferior growth potential of the grazing animal. Other factors contributing to low biological efficiency for forages are low-producing plant species, inadequate techniques for assessing forage nutritive value, overstocking, and large dry matter loss when pastures are grazed or when forages are harvested for storage.

OBJECTIVE: Develop, synthesize, and apply new concepts in forage production, quality evaluation, and animal feeding systems so as to attain optimum efficiency in converting forage crops into livestock products.

RESEARCH APPROACHES:

A. Develop rapid, accurate laboratory procedures for predicting forage quality, intake, and digestibility.

B. Develop more precise methods for measuring intake of grazed herbage and for determining plant and animal factors related to intake, including the effect of aromatic compounds that are characteristic of certain plant species.

C. Re-evaluate certain pasture systems using animals possessing genetic ability for high relative rate of growth.

D. Develop and test sequential grazing systems using superior forage species and superior animals.

E. Develop and test systems of conserving forage for feeding to sheep, and beef and dairy cattle.

F. Define the characteristics of feed supplements that will increase the rate of rumen fermentation for maximizing efficiency of forage use for livestock production.

G. Develop chemical and biological procedures for pretreating stored forages so that feeding value is enhanced.

H. Develop and test recycling systems for forage feeding systems.

CHARACTER OF POTENTIAL BENEFITS: Increased animal production per unit of land; shorter period for animals to reach market weight and grade; earlier calving age for beef and dairy cows; improved animal reproduction; greater flexibility in forage and livestock production systems that reduce risks of financial loss; and a pattern for world wide advancement in efficiency of producing livestock products from forage.

MAGNITUDE OF POTENTIAL BENEFITS: To cut 3 months off the age at which a dairy heifer enters the milking string would save an estimated $30.00 in total feed costs; a well-distributed forage supply may increase calf weaning 100 or more pounds and reproduction efficiency by 10%. Intensive forage livestock systems require higher yielding crops and superior management skills which result in more efficient production of livestock products.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
40	60

TITLE: Nutrient relationships and fertilizer use on forages. RPA 307-H

SITUATION: While yield increases can be obtained through fertilizer applications to forages, these gains are not always translated into improved performance by the grazing animal. Complex soil-plant-animal interrelationships are involved. Non-legume plants generally respond to nitrogen fertilizer with increased forage yields and often with a higher protein content. Legumes respond to additions of phosphorus, potassium and calcium when these are deficient in the soil. Increased capacity and improved animal production should result from improved soil fertility practices and higher forage yields, yet the reverse may be true. Micro-nutrients often limit plant and animal growth. Plant and animal toxicities sometimes occur. The role of endotrophic vesicular-arbuscular (VA) mycorrhizae in plant nutrition is poorly understood. There is evidence, however, that these fungi increase nutrient uptake and that they make less available forms of phosphorus more available to the host. It cannot be assumed that all species of VA mycorrhizae are equally beneficial.

OBJECTIVE: To understand the plant-soil-animal interrelationship so that direct fertilizer responses of the plant can be converted into commensurate gains in animal response.

RESEARCH APPROACHES:

A. Determine the nutrient concentrations which are necessary for optimum plant growth and their effects on animal production.

B. Obtain information on soil-plant-animal interrelations to improve forage quality and quantity and ultimately animal production.

C. Identify specific areas of mineral deficiencies and determine economic levels of fertilizer application.

D. Determine the water-fertilizer interactions to ascertain best levels of fertilization to achieve efficient utilization of water.

E. Determine the effect of mycorrhizae fungi in nutrient uptake and plant growth at various levels of soil fertility.

F. Determine the effect of VA mycorrhizae on the composition of the host plants.

CHARACTER OF POTENTIAL BENEFITS: Increased yield and quality of forages resulting in improved animal production.

MAGNITUDE OF POTENTIAL BENEFITS: An average increase in yield of forages of 3% translated into increased animal production would be valued at 120 million dollars annually.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
25	35

TITLE: Equipment for establishment, improvement, and maintenance of hay and pasture lands. RPA 308-A

SITUATION: Poor stands and slow growth of forage and pasture lands may often be attributed to planting and fertilizing practices. Getting adequate stands is one of the primary requisites for minimizing cost of production. Effective equipment and practices that minimize hazards to crop stands are invaluable to an agricultural enterprise. Seed and fertilizer placement studies have been conducted for a number of years on several crops. Changing technology and equipment, as well as the addition of herbicides and fungicides and fertilizing practices, require that equipment and methods needed for placement be kept current to realize optimum returns.

OBJECTIVE: To develop new or improved equipment and field practices for the establishment, maintenance, and renovation of pasture and hay lands.

RESEARCH APPROACHES:

A. Develop instrumentation for studying micro-environment, as related to germination and growth of seeds investigated under 307-F.

B. Develop planting and fertilizing equipment that will permit precision placement of seed and fertilizer, desired soil compaction, and moisture retention.

C. Develop equipment for interplanting and fertilizing in sod crops and rows as well as in prepared seedbeds, and equipment for desired fertilizer placement for optimum growth.

CHARACTER OF POTENTIAL BENEFITS: Increase in hay yields and livestock carrying capacities of pastures by reseeding or replanting to improved varieties, interseeding with longer or off-season varieties, and improved fertilization practices.

MAGNITUDE OF POTENTIAL BENEFITS: Over 100 million acres in the eastern half of the U.S. can be benefitted through this research with potential savings ranging up to over $25 per acre or an estimated total of 500 million dollars per year.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
5	5

TITLE: Equipment and methods for harvesting and farm processing forage crops. RPA 308-B

SITUATION: Forage is the largest crop harvested in the United States and outranks all other crops, except corn, in value. Currently, about 85 percent of the hay crop is baled; the rest is handled either long, chopped, wafered, or pelleted. Even though mechanization has doubled the productivity per man-hour since World War II, it has not kept pace with such crops as grain where mechanization has increased productivity fivefold. In addition, preventable losses occurring during hay harvesting and handling average 20 percent. Silage making is better mechanized than hay making. However, present practices require the handling and storing of approximately twice as much water as dry matter. Fermentation and seepage losses, except in very expensive, sealed silos, average 20 percent.

OBJECTIVE: Develop principles, methods, and equipment which will reduce the cost of producing and processing forage, facilitate handling and storage, and increase the nutritive value of the crop.

RESEARCH APPROACHES:

A. Investigate practical and low unit cost methods of forage harvesting that will reduce the possibility of damage from unfavorable weather conditions.

B. Develop less expensive methods of moisture removal.

C. Evaluate baling, pelleting, and wafering methods of processing for different forages and determine capacities, and size of farm operations, at which processing may be economical.

D. Develop economical farm methods of handling and storage for the various harvesting systems for subsequent on-farm processing.

E. Investigate the possibilities of enhancing the nutritive value of forage by on-th-farm processing.

CHARACTER OF POTENTIAL BENEFITS: Both reduce and change the character of labor required and, at the same time, retain more of the nutrients in both hay and silage and to consolidate hay into a form which can be more economically transported.

MAGNITUDE OF POTENTIAL BENEFITS: Through the use of new or improved equipment and systems for harvesting and farm processing hay, labor requirements could be reduced to one man-hour per ton. The resultant dollar savings together with a saving of 80 percent of those nutrients now lost would amount to 387 million dollars annually based on a production of 125 million

tons. With a completely mechanized system for silage production combined with a reduction of total losses to 5 percent, potential annual savings of 150 million dollars are possible based on a 100 million ton crop.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
15	22

TITLE: Equipment for harvesting and processing of forage, pasture, and range seed. RPA 308-C

SITUATION: The United States has become the leading country in forage, pasture, and range seed production with more than $175,000,000 worth marketed annually. Although some improvements have been made and adopted in recent years, very substantial improvements are needed in the efficiency of cleaning equipment available to producers. Therefore, much of seed is not marketable because of contaminants. Harvesting equipment such as combines presently in use for seed production were originally designed for grain and leave much to be desired in efficient operation, both from the standpoint of losses and damage to small legume and grass seed.

OBJECTIVE: To develop more efficient harvesting and threshing components for combines and equipment for cleaning and separating for on-the-farm processing.

RESEARCH APPROACHES:

A. Study the various components of the conventional combine to determine where and to what extent they contribute to loss and seed damage.

B. Design and develop combine components and techniques which will reduce losses and yield higher percentages of viable seed.

C. Investigate seed separation methods based on physical characteristics of the seed such as length, width, specific gravity, electromagnetic response, seed coat characteristics, and others which may lead to the design of new equipment to make effective seed separations.

CHARACTER OF POTENTIAL BENEFITS: Reduce seed loss and damage in harvesting and cleaning. Substitution of equipment for labor in the harvesting and processing operations.

MAGNITUDE OF POTENTIAL BENEFITS: Through the use of better harvest timing and improved harvesting machines and methods, 85 percent of the crop loss could be prevented. Seed cleaning and separating losses average 40 percent with light fluffy grasses and 15 percent with legume seeds. It is estimated that better methods for handling and processing could reduce current losses by 75 percent.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
5	6

TITLE: Systems analysis for forage and pasture use. RPA 309-A

SITUATION: Livestock producers depending largely on forage and pasture have some alternatives to choose from in selecting methods of management and utilization including use of supplementary feeds and overwintering practices. The optimum selection for individual farms varies due to differences in topography, soil productivity, feasibility of brush removal and stand improvement, type of livestock grazed, size of operation and other resources under the control of the operator. The proper choice from the alternatives available would provide for optimum use of available land, labor, livestock and supplementary feeds, and other inputs in utilizing the forages grazed. Mathematical models are needed to simulate the variables and alternatives for systems applicable to ranches and farms varying in resources and kind of livestock grazed.

OBJECTIVE: To combine that set of grazing management, forage production, and supplementary feeding practices which will result in the most economical production of meat and animal by-products and that will optimize income for the entire farm operation.

RESEARCH APPROACHES:

A. Identify factors associated with yields, carrying capacities, forage quality, livestock gains, and labor utilization in the production and use of forage and pasture crops.

B. Develop and use mathematical models for simulating alternative grazing and forage systems adapted to farms varying in resources.

C. Test hypothetical forage and pasture management systems to determine which combination of practices, equipment, labor, and other resources result in optimum production of livestock and livestock products.

D. These alternative forage production management and utilization practices and systems also need to be tested on a whole farm basis to determine the relative profitability for units varying in resources, kind of livestock produced, and managerial skills of the operator.

CHARACTER OF POTENTIAL BENEFITS: Optimizing net income to livestock ranches and farms.

MAGNITUDE OF POTENTIAL BENEFITS: Data are not now available to estimate potential benefits. System analyses for forage and pasture use become more valuable when they are based on the entire farm operation. Benefits of improved grazing and forage feeding systems must include the impact of

managerial skills and practices followed in producing and buying other inputs, and in the quality and price received for the livestock and livestock products sold.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
5	6

TITLE: Systems analysis for rotation forage crops. RPA 309-B

SITUATION: Producers of forage-consuming livestock have many alternatives to choose from in selecting forage crops to grow, methods, machines and equipment to harvest and handle them, facilities to store forages in, and combinations of forage and concentrates to feed. The optimum selection for individual farms varies due to differences in topography, soil productivity, type of livestock produced, size of operation, and other resources on the farm. The optimum choice for an individual producer would economize in the use of land, labor, equipment, and other inputs in the production of milk and meat. Mathematical models need to be developed to simulate the variables and alternatives for complete forage systems applicable to farms varying in resources and kind of livestock produced.

OBJECTIVE: To combine that set of forage production, grazing, harvesting, storage, and feeding practices that will result in the most economical production forage crops for farms varying in resources. The next step is determination of the most profitable combination of forage crops and practices, grain and supplementary protein, labor, and other inputs on a whole farm basis.

RESEARCH APPROACHES:

A. Identify factors associated with yields, quality or feeding values, losses in harvest and storage, feeding efficiency, and labor utilization in the production of harvested forage crops. Calculate investments and annual costs for alternative forage harvesting and handling machines and equipment, and different types of storage facilities. Specify those factors requiring additional research.

B. Develop and use mathematical models for simulating alternative forage systems adapted to farms varying in resources.

C. Test hypothetical forage systems to determine which combination of crops, practices, equipment, and grazing, harvesting, storage and handling methods, and concentrates and other inputs result in high and economical production of milk and meat from harvested forages.

D. Test these alternative forage production, management, harvesting, and utilization practices and systems on a whole farm basis to determine the relative profitability for farms varying in size, other resources, kind of livestock produced, and managerial skills of the operator.

CHARACTER OF POTENTIAL BENEFITS: Optimizing net income on livestock farms.

MAGNITUDE OF POTENTIAL BENEFITS: The task of estimating potential benefits

to the livestock industry is enormous and must be delayed until a later date. It is generally recognized that net returns to large numbers of dairy and beef fattening farms could be increased appreciably by selection of crops and practices which increase yields and lower costs. Systems analysis for forages become more realistic and useful when they include an analysis of the entire farm operation. Benefits from more economical forage systems must also take into account the impact of variability in efficiency of cattle in converting feed to milk and meat and managerial skills and practices used in producing or buying other feed crops and inputs, and the quality and price received for the milk and meat sold.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
2	3

TITLE: Production for improved consumer acceptance of forage-fattened cattle. RPA 405

SITUATION: In the past, pasture-fattened cattle were old when slaughtered. The meat was tough and the fat covering pigmented. Under present day practices slaughtered steers are sold under 2 years of age and fat pigmentation from grass is not a major problem. Old cull cows do yield pigmented fat covering, but since this meat goes into hamburger or processed meats, the pigmented fat does not appear to be a problem of economic importance. However, there is a wide variation in carcass merit in slaughter cattle. Progress has been slow, but techniques are now available so that rapid improvement in carcass quality should be made.

OBJECTIVE: Devise forage-feeding systems adequate to grow cattle to slaughter weight and grade at 12-14 months of age and thereby improve consumer acceptability of carcasses of forage-produced beef.

RESEARCH APPROACHES:

A. Make full use of the Federal Meat Grading Service for assessing carcass merit of forage-fattened beef.

B. Select the kind of animals and grazing system that will insure rapid growth and fattening of young cattle.

C. Cooperate with food marketing research personnel to help create a better image for forage-fed slaughter cattle.

CHARACTER OF POTENTIAL BENEFITS: Uniform high quality in beef carcasses will increase consumer demand for beef. An improved image for forage-fed beef should benefit livestock producers.

MAGNITUDE OF POTENTIAL BENEFITS: Consumer assurance of uniform quality in forage-fed beef should increase sales and return producers more money.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
3	3

Research applicable to this problem area will be conducted under RPA 307-G.

TITLE: Low cost processes for preparation of stable, palatable leaf protein products for human foods. RPA 406

SITUATION: Over a ton of protein is produced per acre by alfalfa managed for dehydration. This is about double the amount obtained from the best of the seed crops (e.g., soybeans, cereal grains, etc.). Experimentally produced leaf protein products contain a good balance of essential amino acids and, depending on the method of preparation, may contain substantial amounts of essential minerals and vitamins.

Considerable research has already been done on wet processing of leaf materials to produce human foods by British, Japanese, Hungarian, as well as American workers. The products produced thus far have been unpalatable and yields have been poor based on protein content of the raw material. The protein quality is susceptible to damage presumably due to the presence in the leaf of reducing carbohydrates which react readily with free amino groups in the protein.

Research has been conducted on dry separation processes for preparation of high protein leaf products from alfalfa hay and dehydrated alfalfa. While products of up to 30% protein have been obtained they still contain more fiber (e.g., 14-15% crude fiber) than is desirable in a human food, and contain undesirable color, odor, and flavor characteristics. Hand dissection studies indicate that further fiber removal is possible if means could be developed to separate leaf parenchyma from the midrib and vein tissues and from residual stem and petiole fragments.

Analytical data on high protein products from leaf and feeding experiments with animals and human beings have been encouraging, but the problem of palatability remains unsolved. Fresh or freeze dried alfalfa has a more acceptable flavor than dehydrated alfalfa. Therefore, an important part of the problem lies in changes which occur during processing. Recent research has shown that linolenic acid is the chief fatty acid of forage lipids. These lipids are closely associated with the leaf protein of both intact leaf and in protein isolates. It seems likely that autooxidation of linolenic acid during and after processing may be a major contributor to the flavor problem. The high potassium levels in all types of leaves and saponins of legumes leaves are probably involved in the bitterness of leaf protein preparations.

OBJECTIVE: To develop new or improved low cost processes for preparing low fiber, stable, palatable food products rich in biologically available amino acids from green leaf materials.

RESEARCH APPROACHES:

A. Processing of fresh leaf by pressing to separate a protein

containing juice from the fibrous residue and recovery of the protein from the juice in palatable stable form.

B. Development of high protein leaf products by field stripping the leaf from forage plants followed by careful drying or otherwise preserving the product so as to produce stable palatable food products.

C. Development of palatable high protein food products from separated leaf fraction of dehydrated forages.

D. Investigate forage components and component interactions to support the above process research.

CHARACTER OF POTENTIAL BENEFITS:

A. New high protein food source from materials presently used only as feed.

B. Expanded cash crops for farmers.

C. New export products for U.S. to improve balance of trade.

D. New industry for rural redevelopment.

MAGNITUDE OF POTENTIAL BENEFITS: From the character of the benefits it is apparent that the magnitude will be very large although a specific dollar value cannot be assigned at this time.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
3	6

TITLE: Improved feed use of forages. RPA 407-A

SITUATION: Most harvested forages are preserved for year around use as either hay or silage. In spite of improvements in these traditional means of preservation, losses of up to 30-40% of nutrients may occur through leaf shattering, rain leaching, mold spoilage during haying, or through fermentation losses, liquid drainage and surface spoilage during ensiling and storing. During the past 30 years forage dehydration has developed on a substantial basis (over 1,700,000 tons last year). Dehydrated forages have not been used, as yet, as a primary feed source in competition with hay or silage. Their use has been largely as supplements to supply specific nutrients such as xanthophylls, vitamins, and unidentified growth and reproduction factors (U.G.F.). Costs of dehydrated products have been reduced through increased efficiency to such a point that in some markets dehydrated alfalfa pellets are competitive with sun-cured alfalfa pellets.

Further reduction in costs of dehydration are possible through mechanical dewatering prior to dehydration but research is needed to develop usable processes. Such a development could reduce costs of dehydrated forages below costs of hay and lead to revolutionary changes in animal production.

Although it is the best system yet devised for forage preservation, dehydration, as presently carried out, causes serious losses of economically important nutrients, including xanthophylls (important poultry and egg pigmenters), carotene (pro-vitamin A), tocopherol (prevents oxidized flavor in milk, etc.), other natural antioxidants, lysine, and U.G.F. In addition, further losses occur during storage subsequent to dehydration. These losses are reduced by inert gas storage and the application of ethoxyquin. Residual losses can be serious, especially when considerable time lapses between shipping and consumption by the animal. Recent research has shown that lutein comprises about 75% of the total xanthophylls of dehydrated forages. Dehydrated alfalfa lutein has a biological availability of only about 60% compared with the lutein of alfalfa extracts.

OBJECTIVE: To develop new and improved methods of dehydration or other off-the-farm conversion of forages into stable products rich in labile nutrients.

RESEARCH APPROACHES:

A. Develop mechanical dewatering processes to lessen the cost of dehydration and develop methods for utilizing the removed "water" in liquid feeds, reconstituted grains, etc.

B. Develop improved dehydration processes and dehydrator control

systems to minimize losses of labile nutrients.

C. Investigate methods of converting the quinones of forages to chromenes and chromanols to enhance the stability of products.

D. Develop improved antioxidants, antioxidant synergists, and pro-oxidant inactivators for forages.

E. Develop improved methods for prevention of enzymatic nutrient losses.

F. Develop means of improving the biological availability of forage xanthophylls.

CHARACTER OF POTENTIAL BENEFITS: The competitive position of dehydrated forage would be improved both in domestic and foreign markets if lower cost, stable products richer in biologically available labile nutrients were developed. Specifically these benefits include: expanded cash crop for farmers, expanded industry in rural areas, lower priced animal products for consumers, and expanded export market for dehydrated forages.

MAGNITUDE OF POTENTIAL BENEFITS: Prevention of losses of nutrients during dehydration and storage of dehydrated forages, and improvement of biological availability of nutrients would amount to about $170,000,000 annually. Reduction of dehydration costs through mechanical dewatering would result in additional savings.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
15	20

TITLE: Processes to increase digestibility of lignified plant materials. RPA 407-B

SITUATION: Traditionally, ruminant animals have existed mainly on forages which consist largely of cellulosic materials along with ncessary protein, vitamins, minerals and the like. The rumen bacteria are able to degrade much of the cellulose to make the organic acids that provide the ruminant energy for maintenance and growth of production. Some cellulose-rich materials cannot be utilized effectively by rumen bacteria, however, because the cellulosic fibers are closely associated with lignin, which inhibits cellulose digestion.

A number of important agricultural residues fall in this latter category. They are high fiber materials which have been brought to the factory or processing plant as part of a harvested commodity and have been separated-out or left-over after processing. Examples of such high lignin agricultural products include oilseed and cereal hulls, sugarcane bagasse, and alfalfa stems; and from the lumber industry, sawdust. Other residues such as cereal straws could be collected at a moderate cost in some locations. Present day technology does not permit utilization of these materials as energy rich feedstuffs and their feeding role is as roughage sources only. In one exception to this, the Commissioner of Food and Drugs recently approved an extractive derived from wood as a molasses substitute. In work at several universities it has been established that very fine grinding increases the digestibility of high fiber products, but fine grinding costs are high and the resulting flour products are unpalatable to ruminants. In times of extreme scarcity, cereal straws have been treated with alkali to increase carbohydrate digestibility for feed use, but ordinarily, this is not economical. Current work shows promise for high pressure steam treatments of alfalfa stem.

The products under consideration contain 55 to 70 percent of potentially digestible carbohydrate and 2 to 13 percent protein. If the 10 to 30 percent lignin content which makes these nutrients biologically unavailable could be disrupted or removed a fast new feed supply would become available.

OBJECTIVE: TO develop low-cost methods to increase the biological availability of the carbohydrate and protein associated with lignified tissues in agricultural products and residues to permit their use as high energy ruminant feeds.

RESEARCH APPROACHES:

A. Development of processes to increase the biological availability of carbohydrate and protein in high fiber feed materials by physical process treatments such as heat, shear, radiation, etc.

B. Development of processes to increase the biological availability of carbohydrate and protein in high fiber feed materials by use of chemical treatment to remove or disrupt lignin.

C. Development of processes to increase the biological availability of carbohydrate and protein in high fiber feed materials by biological or fermentative methods.

D. Carry out the necessary basic work to support the above applied research.

CHARACTER OF POTENTIAL BENEFITS:

A. Beneficial utilization of unused agricultural residues.

B. Elimination of waste disposal problem for agricultural processing residues.

C. Lower production costs and consumer prices for meat and dairy products.

MAGNITUDE OF POTENTIAL BENEFITS: Increasing the biologically available energy in 100,000,000 tons of selected agricultural residues would increase their value by about one billion dollars, based on computer evaluation of energy costs for ruminants. Assuming that it was economically feasible to collect and process substantial quantities of residues, annual benefits could reach $500,000,000. In all probability lesser benefits would be realized in the immediate future.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
8	10

TITLE: Development of forage products rich in unidentified growth and reproduction factors and free of deleterious constituents. RPA 407-C

SITUATION: Alfalfa, clovers and grasses are known to contain unidentified growth factors for lower organisms (microorganisms, snails, and insects) as well as for warm-blooded animals (guinea pigs, poultry, and swine). Work with ruminants suggests that unidentified nutrients which affect nutrient utilization (fiber, urea) may exist although such factors probably operate through effects on rumen organisms. In addition, specific forage plants are known to contain inhibitors of widely varied nature (metal chelating agents, nutrient antagonists, saponins, enzyme inhibitors, mycotoxins from molds growing on the forages, and toxins). Maximum utilization of processed forages is dependent upon a thorough knowledge of the nature and effects of all biologically active forage components and development of processing methods for making products of maximum nutritional value.

OBJECTIVE: To develop processes or other means for conserving desirable components of forages and for eliminating or neutralizing the effects of deleterious components.

RESEARCH APPROACHES:

A. Isolate and determine the chemical nature of the beneficial and deleterious unidentified components of legumes (esp. alfalfa) and grasses.

B. Develop sensitive, rapid chemical procedures for their quantitative determination for use in process studies, plant breeding, etc.

C. Develop means for preservation of and enhancement of levels of desired forage nutrients.

D. Develop means of destroying, neutralizing or otherwise reducing levels of undesirable components in forages.

CHARACTER OF THE POTENTIAL BENEFITS:

A. Expansion of use and markets for processed forages.

B. Reduction of cost of livestock production.

C. Provision of methodology for plant science approaches to improved forage crops.

MAGNITUDE OF POTENTIAL BENEFITS: The benefits are difficult to quantify but are estimated to be in the range of $17,000,000 per year for dehydrated alfalfa alone.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
2	2

TITLE: Detection and estimation of chlorinated insectide residues in animal products and feeds. RPA 408

SITUATION: Most chlorinated pesticides and their metabolites have the unfortunate property of persisting for a long time in the environment. When they are ingested by livestock, either in feed or through the skin, they accumulate in body fat and are eliminated slowly in such products as milk and eggs. A single heavy dose of pesticide ingested by a dairy cow will result in appreciable residues in milk for many months. Present Federal Regulations are stringent as to the amount of chlorinated pesticide residue allowed in dairy products. It is therefore vital that chlorinated pesticide residues in feed for dairy cows be kept at a minimum as contaminated feed can and has resulted in milk from dairy herds being condemned for long periods of time. Dairy products and other agricultural products need to be checked routinely, also, so that contaminated products do not enter marketing channels.

Although great progress has been made in the analysis of dairy products and feeds for chlorinated pesticide residues, such analyses are still expensive and time-consuming. At present, an analysis for chlorinated pesticide residues costs $15. There is a need for simpler and less expensive procedures.

OBJECTIVE: To develop fast, simple, inexpensive methods for routinely checking milk and other animal products and feeds for chlorinated pesticide residues. This would save substantially on present costs of analyses and make more testing of agricultural products economically feasible.

RESEARCH APPROACHES: The analysis consists of three basic operations:

A. Extraction of pesticide from the product with suitable organic solvents.

B. Separation of pesticides in the crude extract from other interferring materials so far as possible.

C. Analysis of the purified extract, usually by paper, gas, or thin-layer chromatography.

Each step will be studied in detail to shorten and simplify it, while at the same time retaining accuracy.

1. Extraction methods will be evaluated on the basis of simplicity and effectiveness in extracting residues.

2. Rapid column chromatographic technique will be used for separation of pesticides from interferences in crude extracts.

3. Studies will concentrate on improved methods of analysis by thin-layer chromatography which is rapid, inexpensive, and sensitive.

CHARACTER OF POTENTIAL BENEFITS:

A. Lower costs in monitoring agricultural products for chlorinated pesticide residues.

B. Capability of testing more samples for residues.

MAGNITUDE OF POTENTIAL BENEFITS: The current cost of having a sample analyzed commercially for chlorinated pesticide residues is $15. Cutting this cost in half to $7.50 would result in an annual saving of $750,000 assuming analysis of 100,000 samples/year.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
8	9

TITLE: Improved market grades and standards for forages. RPA 501

SITUATION: Grades and standards in the marketing system should provide meaningful communication with respect to quality (ultimate feeding value of forage) of a product in relation to its price. Objective, quick, and accurate measures for characteristics of economic significance are needed. The increasing trend toward separation of animal agriculture from the traditional production of feed crops and the resulting shift toward more custom and contractual production of forage crops emphasizes the importance of developing more meaningful grades for hay, pellets, wafers, and silage. U.S. grades, based on color, leafiness and other physical characteristics often have little relationship to feeding values. Low cost and accurate laboratory and field methods for testing for forage digestibility, protein and other factors influencing animal intake and performance need to be developed.

OBJECTIVE: To provide grades and standards that will effectively communicate value differences for varying gradations in nutritive value (quality).

RESEARCH APPROACHES:

A. Evaluate the effectiveness of presently used grade standards and methods of measuring and valuing forage quality as it affects animal performance.

B. Develop descriptive terminology for grade standards which will characterize the different feeding attributes of kinds and forms of forage so as to facilitate communications between buyers and sellers.

C. Develop quick and low-cost laboratory procedures for measuring digestibility and other attributes of forages.

D. Establish a uniform system of grades recognizing those characteristics which reflect value through utilization in livestock feeding programs.

CHARACTER OF POTENTIAL BENEFITS: Provide improved guidelines in establishing values which are equally well understood and fair to both sellers and buyers.

MAGNITUDE OF POTENTIAL BENEFITS: Insufficient data are available to estimate potential benefits. Effective grades and standards can assist buyers in obtaining forage characteristics they desire and sellers in obtaining appropriate compensation for what they sell. Costs of buying

and selling forage crops could be greatly reduced if such standards were available.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
4	5

TITLE: Marketing efficiency. RPA 504

SITUATION: There is continuous public concern about the tendency for price spreads to increase between what farmers get and prices paid by consumers. At present, marketing services cost more than twice as much as the farm value for agricultural products. Public concern is especially focused on the performance of the marketing system when lower prices are received by producers or higher prices are paid by consumers. New technologies adopted by farmers to attain economies in production lead to lower unit costs of production and excessive market supplies. On the other hand, consumers of farm products continue to demand additional services in marketing which increase distribution costs. The marketing segment of the economy is expected to function in a manner that will resolve these conflicting forces. There is need to determine accurately how new trends in cropping and livestock production affect the demand for kinds and varieties of forage seed. Information is needed to help in matching seed production with seed needs to the benefit of both seed producers and seed users, and to facilitate the orderly distribution of seed in domestic and export channels.

OBJECTIVE: The objectives of marketing efficiency research are to (a) determine alternative methods that result in increased efficiency and lower costs of marketing, (b) evaluate the impact of increases in efficiency on the performance of the marketing system, and (c) provide consumers with choices they desire.

RESEARCH APPROACHES:

A. Formulate problems in terms of economic consequences or issues involved.

B. Select hypotheses that are accepted or rejected on the basis of economic theory and principles.

The specific methodology employed depends upon the type of data and the nature of problems for which solutions are sought. Techniques of analysis draw heavily from the disciplines of mathematics, statistics, economics, and engineering. The complexity in techniques of analysis range from the purely descriptive to simulation models of an entire marketing system for particular farm commodities. Analyses are conducted on the basis of both secondary data and primary data generated by obtaining information from farmers, marketing firms and consumers.

CHARACTER OF POTENTIAL BENEFITS: The need for marketing efficiency research is built around questions arising from changes in the marketing system and the structure of agriculture, the forces causing these changes

and the effects of change in the income and power position of all participants including farmers, marketing firms and consumers. Without a continual flow of objective information upon which to make intelligent decisions and adjust to change, the efficiency of the marketing system can be greatly impaired, resulting in higher costs of moving the Nation's output of forage seed, forage, and processed forage products from the farmer to the consumer.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
4	6

TITLE: Expansion of foreign markets for U. S. farm products: dense, stable, low-fiber forage products. RPA 601-A

SITUATION: The export market for forage products which has grown from practically nil in 1958 to over 350,000 tons in 1967 is based primarily on use in manufactured poultry rations as a source of xanthophylls, carotene, tocopherol and UGF (unidentified growth and reproduction factors). These are nutrients which are labile during processing and storage. In order to obtain these nutrients, foreign customers must pay freight on over a hundred and fifty thousand tons of cellulose, pentosans, and lignin which have little or no value for poultry. The desired nutrients are concentrated in the leaves and are approximately proportionate to the protein content of forage products. Dehydrated forages presently exported are largely 17% protein alfalfa pellets, but grasses, especially of the Southeastern States are good potential raw materials for export products. Sales of processed forages are entirely in dollar sufficient countries and competition is already appearing in the form of increased production in France, Israel, Argentina, Australia, etc.

The growth of mixed feed industries in Japan, West Germany, Great Britain, etc., gives promise of expanded markets for dehydrated forages from the U.S., but it is essential that costs of nutrients at the point of use be reduced to a minimum in order for the U.S. to retain its present markets and to gain its share of the expanding markets in the future. This will require development of concentrated, high density, more stable products.

Research on differential milling to separate dehydrated alfalfa into leaf and stem fractions is already being commercialized even though present methods achieve only about 60% of the potential efficiency as defined by hand dissection studies. Further researches on alfalfa separation are needed and research should be undertaken along similar lines on dehydrated grasses. Present researches on new wet separations for making fiber-free protein-xanthophyll concentrates from alfalfa should be expanded and carried through to develop low-cost processes and products.

OBJECTIVE: To develop economical processes for making high density products which are low in fiber and high in protein (30-50%), xanthophyll (600-15,000 mg/lb), and other desired nutrients from forages for the export market.

RESEARCH APPROACHES:

A. Improvement of differential milling procedures for separation of leaf and stem fractions from dehydrated alfalfa and grasses.

B. Development of processes, for separation of fresh forages into essentially fiber-free protein-xanthophyll concentrates, UGF concentrates and a ruminant feed rich in digestible carbohydrates.

CHARACTER OF POTENTIAL BENEFITS:

A. Increased export markets due to introduction of products better adapted to end use.

B. Reduction in freight costs.

C. Improved U.S. balance of trade.

MAGNITUDE OF POTENTIAL BENEFITS: Based on projected increases in mixed feed usage in western Europe and Japan, superior forage products should find increased markets in these countries. It is estimated that exports could increase by $44,000,000 in 1975. Substantial benefits would also result from improved marketing opportunities in Central and South America.

RECOMMENDED RESEARCH EFFORT:

TF Program Recommendations

1972	1977
2	3

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TITLE: Foreign demand prospects for processed forage products and forage seed. RPA 601-B

SITUATION: Our U.S. farm economy has become increasingly dependent upon foreign markets. Such markets are expanding along with the rapid economic development of some countries, the industrialization of such countries as Japan, and the emergence of regional organizations such as European Economic Community. Research is needed to determine the future demand for existing and for new products from the U.S. agricultural industry.

OBJECTIVE: To develop an analytical framework for projecting short and long term foreign demand and estimate export market potentials for U.S. agricultural exports of selected commodities. These commodities include processed forage products and forage seed.

RESEARCH APPROACHES: On basis of past and current developments and trends, analyze factors (both singly and in combination) affecting future foreign demand for alfalfa leaf meal, other processed forage products and seed. Analytical frameworks will be developed to project future levels of international trade in seed and forage products and to weigh the importance of factors and trends including technological developments affecting future consumption and trade patterns and levels.

Foreign demand prospects will be projected for major importing countries and trade areas, and aggregated to obtain estimates of the future volume of trade in seed and forage products. After determination of the potential level of trade, specific emphasis will be placed upon comparative advantage of major supplying countries or areas. Also the competitive factors determining the probable share of the potential world market to be held by the principal suppliers will be assessed.

TASK FORCE RECOMMENDATION: That consideration be given by the appropriate Task Force to opportunities for expanding export markets for forage seed and processed forage products.

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